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A Pilot Study of Human Response to General Aviation Aircraft Noise

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1.0 INTRODUCTORY SUMMARY

A pilot study has been performed to evaluate procedures for measuring the magnitude of the noise impact – in terms of aircraft noise levels and community response – around Torrance Municipal Airport – a typical large general aviation (GA) airport located in Southern California. This pilot study provides information on methods for evaluating the intrusive characteristics of general aviation aircraft noise, and the resultant response of residents exposed to this noise. Study results may serve as a basis for evaluating basic elements influencing the design of a comprehensive program to determine the character and severity of aircraft noise impact at the more than 7,000 general aviation airports throughout the nation.

Although this pilot study used a small sample size, the results provide valuable information for constructive evaluation of the methodology.

The major elements influencing annoyance to residents impacted by aircraft noise are schematically shown in Figure 1. Exterior noise, from aircraft and nonaircraft sources, is transmitted to the inside of the residence where it competes with interior noise sources for the subject's attention. In this report, alternate methods are explored for evaluating how a subject reacts to noise through a sequence of individual events, such as aircraft flyovers. A method for observing each of these reactions is first analyzed, then methods are used to form a composite picture of the subject's response to general aviation noise. The methods include:

- A quantitative description of the acoustical events which make up the noise environment,
- A technique for self-evaluation of annoyance to individual events by each subject, and
- A search method for identifying for those factors other than noise which may mediate the annoyance response.

Data are interpreted in terms of the information provided through a Wyle noise recording system placed within each residence, and a permanent monitor system maintained by the airport with nine monitor stations located throughout the community.

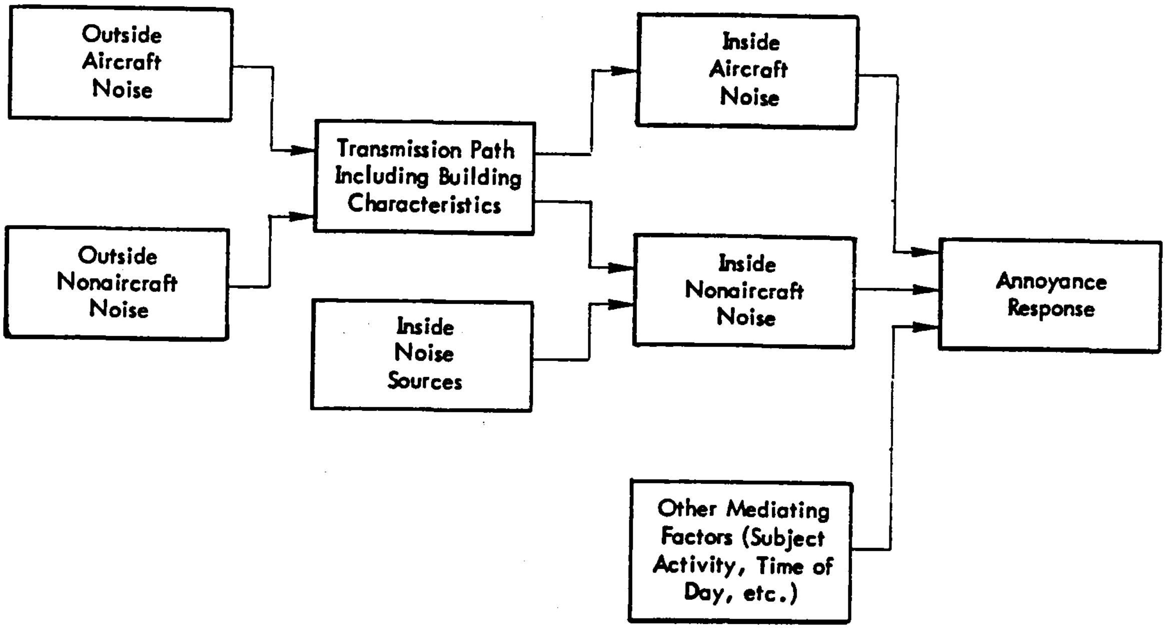


Figure 1. Block Diagram of Elements of Annoyance Response to Aircraft Noise

1.1 Summary of Pilot Study Results

In this evaluation of methods for correlating the response of impacted residents to general aviation aircraft noise, there were several specific stimulus/response problems to be evaluated. Following are brief comments on results of the program in resolving these problems:

- Human response related to activity - is noise annoyance from general aviation aircraft dependent on activity interference? The subject's activity was self-recorded by each subject in the pilot study. Although general conclusions regarding the importance of subject activity are not possible with the small sample size, it was clear that this method of identifying the subject's activity pattern is feasible and potentially applicable on a larger scale.

- Is there a relationship between the variation of measured annoyance and instructions given to subjects? Subject response showed large variability both in average annoyance and in the number of entries in the subject's annoyance diary. However, this variability did not appear to be related to the alternate versions of instructions to the subjects.

- What is the relationship between annoyance and the indoor noise signature of individual aircraft flyovers? The measurement methodology utilized for aircraft noise measurements showed that the average noise levels due to general aviation aircraft were often less than the noise levels of other nonaircraft events. This is one of the more important findings of this study and clearly emphasizes the importance in properly assessing the intrusiveness of the relatively moderate single event noise levels associated with most general aviation aircraft.

- Annoyance predicted by specific noise metrics - which metrics appear to best describe subjective reaction to GA aircraft noise? Among the noise metrics studied, outdoor maximum A-weighted noise level of the aircraft showed the best correlation with annoyance at high noise levels. Statistical levels (i.e., L_0 and L_{10}) measured indoors were not, however, reliable measures of aircraft noise intrusion.

- Background noise/intrusiveness - does background noise level affect intrusiveness or annoyance response to individual flyovers? In this pilot

study, the differential between aircraft noise level and background level appeared to be a slightly better noise metric than the aircraft noise level alone.

- o Time of day - is annoyance (as measured in the pilot study) higher at night? The average annoyance response measured in the pilot study rose slightly at night. However, nighttime curfew on airport operations at Torrance Airport limited the number of observations that could be drawn on this issue.

- o What is the nature of the variation of indoor noise level and annoyance with housing construction and orientation? During the planning stage of the pilot study, an initial selection of households was made based on type of construction as well as proximity to airport noise monitoring stations. Although most of these households were not available in the final sample selection during the subject recruitment stage, a modified selection method could be developed that could be employed for a larger sample. (It should be noted that the variation in the individual response of residents to aircraft noise may very well be due to differences in indoor-outdoor noise reduction attributable to differences in building construction.)

1.2 Summary Comments on Methods for Large Scale Study

The pilot study revealed one basic limitation in the chosen methodology. The measure of the acoustic stimulus indoors that was presumably associated with the subject's annoyance responses was restricted to the immediate vicinity of the indoor noise monitoring equipment. However, the study also revealed certain characteristics of general aviation noise near the Torrance Municipal Airport which may be pertinent to a national study. In particular, at the sites selected in this pilot study, the energy average aircraft noise levels usually did not dominate interior noise environments. Annoyance is difficult to measure under these conditions, and it becomes necessary to focus on the single event flyover noise levels for such annoyance evaluation.

Another method which may also be most appropriate for evaluating overall attitudes toward noise in a national study would be to use telephone questionnaires. This could be coupled, for example, with outdoor noise measurements of aircraft noise levels using established noise metrics which quantify single event as well as

composite noise environments. This method would offer a high efficiency in sampling large populations. Results of the pilot study clearly support the need to resolve further details of the nonacoustic cause and effect relationships involved in the annoyance response within each household. However, when large numbers of households are to be surveyed, this assessment of nonacoustic factors can be more efficiently carried out with a telephone survey technique.

1.3 Contents of Report

The general methodology employed in the pilot study is shown schematically in Figure 2. The discussion of these methods in Section 2.0 follows this same structure: preparation for survey, data acquisition, and data analysis. Section 2.0 describes the procedures and most interesting results of the pilot study. Section 3.0 provides overall observations on the results of the study. Section 4.0 draws on these results to make observations regarding the design of a national survey of communities impacted by general aviation aircraft noise.

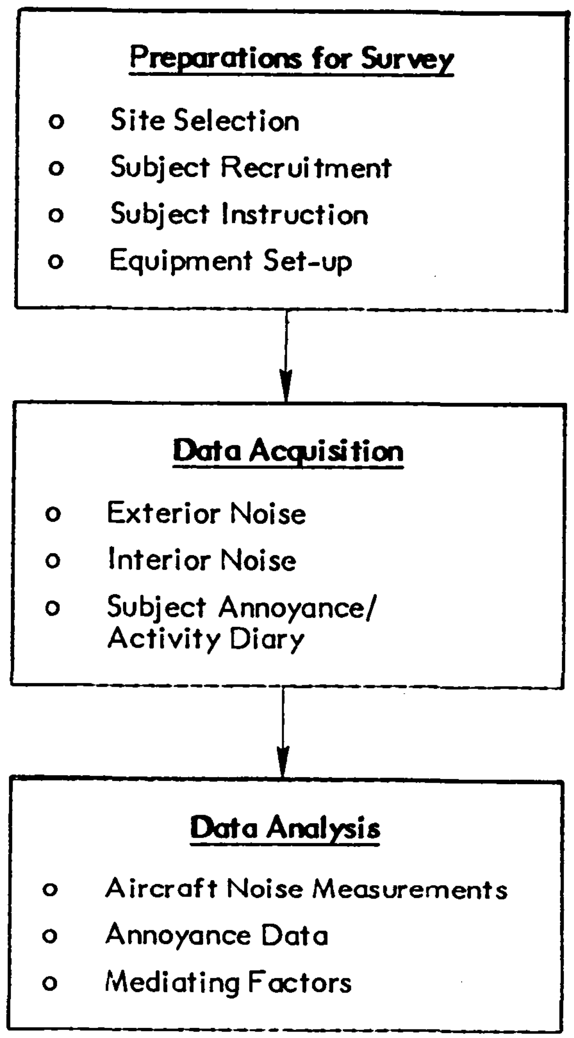


Figure 2. Block Diagram of Pilot Study Methodology

2.0 PROCEDURES AND RESULTS OF PILOT STUDY

2.1 Scope of the Pilot Study

The pilot study was designed to explore a set of specific techniques for evaluating aircraft noise intrusiveness in residences in the vicinity of a large general aviation airport. The pilot study was performed from August through October 1980 in the vicinity of Torrance Municipal Airport, which is one of the busiest general aviation airports in the nation. For the year beginning June 1978, operations totaled over 400,000[1] including arrivals, departures, touch and go's, stop and go's, and low approaches. Most of these operations involved single-engined general aviation aircraft. To minimize noise impact on the community, the airport requires a number of noise abatement procedures. One such procedure is a departure curfew between 2300 hours and 0630 hours.

To monitor compliance with noise abatement procedures, the airport employs a sophisticated computer-based noise monitoring system which records aircraft and community noise at nine permanent locations surrounding the airport. Figure 3 shows the locations of households used in the study and noise monitoring terminals with respect to the airport. Figure 4 depicts the annual CNEL (Community Noise Equivalent Level) contours for the airport based on measured and operational data. Figure 5 presents a sample of the actual flight tracks plotted from regional air traffic radar trackings.

The pilot study comprised a survey of 18 households, each household located near one of the nine Torrance Airport outdoor noise monitoring terminals. Each household participated in the survey for approximately 5 days, during which about 5,000 airport operations occurred. The number of sampled households in the study was statistically small, but sufficient to identify potential problems and their solutions in administering a similar survey with a larger sample size.

The pilot study was, in effect, an experiment in which the basic event of interest is the response of a single person to a single aircraft flyover. In community noise surveys, the detail of acoustic information recorded can vary from general statistical descriptions covering hours or days to specific time histories of individual noise events. For outdoor noise in the pilot study, both long-term and single event details were provided by records from the Torrance aircraft noise monitoring system. Computer printouts from this system provided daily and

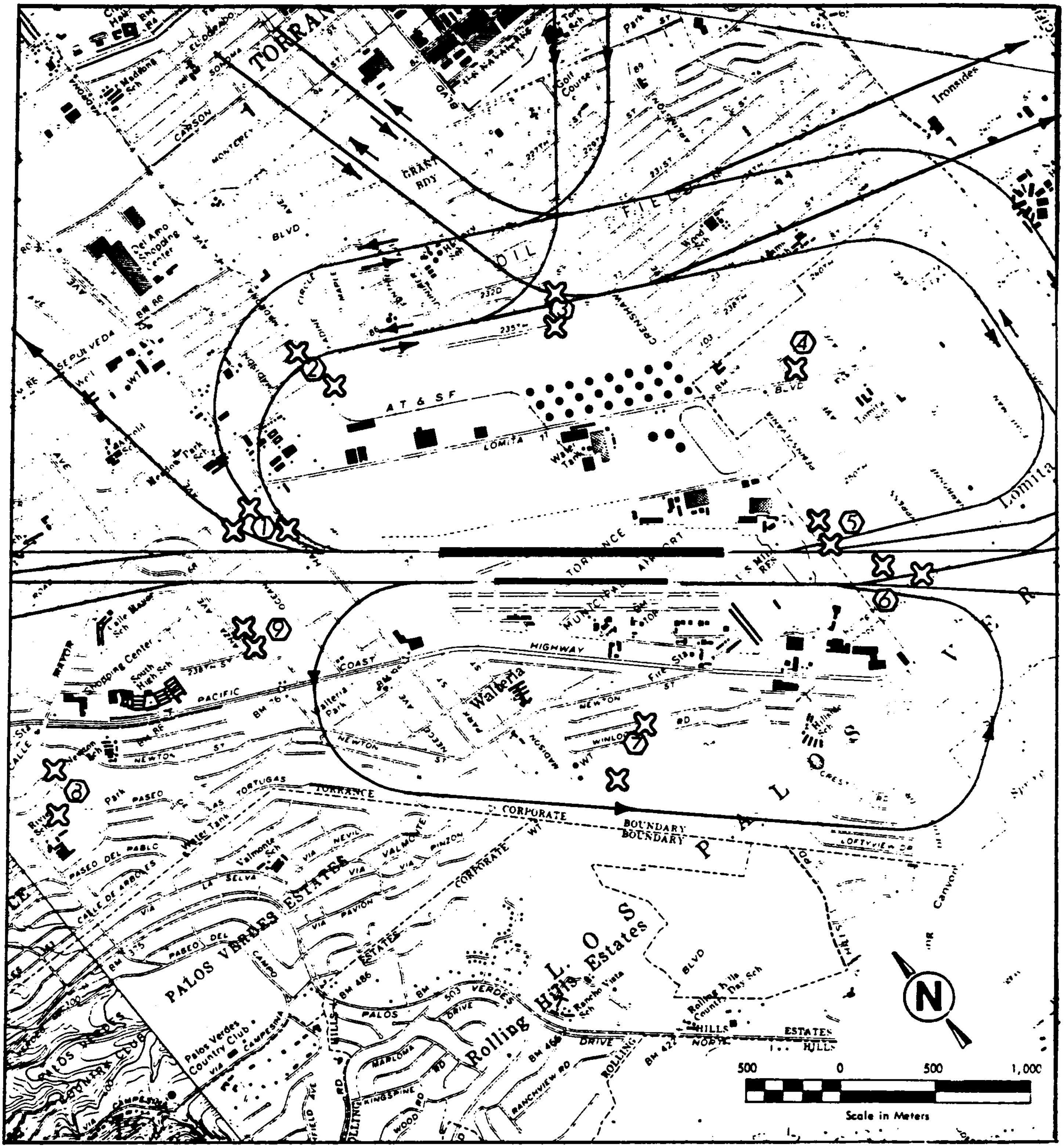


Figure 3. Torrance Airport Noise Measurement Study Area

Airport Noise Monitoring Sites

Residential Monitoring Sites

Flight Tracks

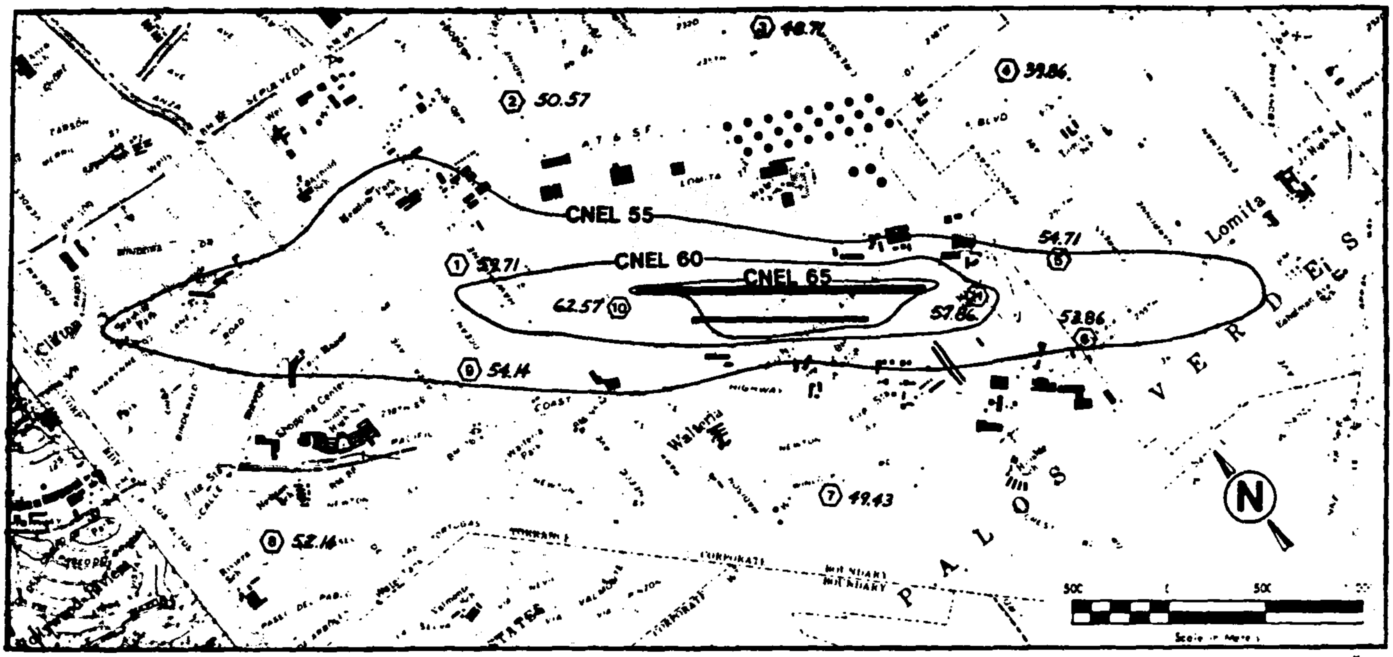


Figure 4. Torrance Municipal Airport CNEL Contours, June 1978 - May 1979

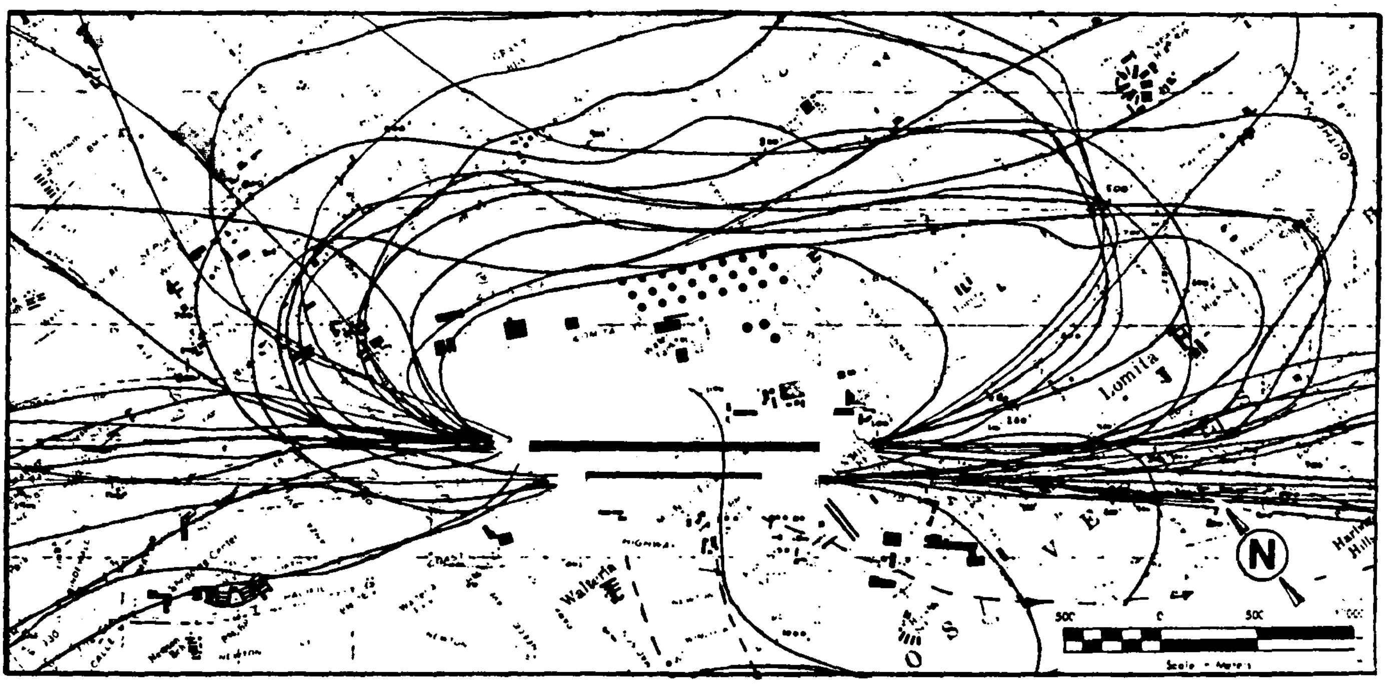


Figure 5. Torrance Municipal Airport Actual Ground Tracks

hourly statistical levels, while stripchart recordings provided maximum A-weighted levels for all individual aircraft. The hourly and daily statistical data is essentially provided "on line" by the system. The stripcharts were obtained at a later time from the recorded data. For indoor noise in the households studied, similar details were provided by recordings made in a single test room using Wyle-installed digital noise level recorders.

Subject response in community noise surveys can be categorized according to the immediacy of the response and the method of measurement. Long-term responses such as general attitudes toward airport noise can be evaluated through personal interviews. Short-term responses include self-evaluations (by the subject) of annoyance due to individual flyovers. These responses can be recorded either in a diary or with an electronic recorder. This pilot study employed the former approach; each subject was given a diary in which to evaluate annoyance according to a six-point scale. The subject was encouraged to make entries in this diary at least two or three times throughout the day.

In addition to the absolute level of the aircraft noise, factors which determine the intrusive character of the noise are indoor ambient noise levels, time of day, and subject activity when the annoying event occurred. Indoor noise data were obtained through the digital recordings; activity/annoyance data were obtained from the subject's diary. Other factors influencing intrusiveness include subject prestress due to other bothersome noise sources, the sound transmission characteristics of the home, and subject activity as recorded in the diaries. These factors were investigated in very limited detail, however, in this pilot study.

In summary, the Torrance pilot study is a small-scale community noise survey employing the outdoor airport noise monitoring system, indoor digital sound level recorders, and subject activity and annoyance diaries. While the small sample size minimizes the statistical significance in the results, these results do provide a useful appraisal of the general methods adopted for this survey.

2.2 Preparation for the Survey

Preparation for the pilot study involved selection of participating households, recruitment and instruction of subjects, and set-up of acoustic measurement equipment.

2.2.1 Site Selection

Each of the 18 households chosen for the sample survey was less than 300 m from one of the nine airport noise monitoring stations. Figure 6 shows a typical arrangement of households (Sites 1A, 1B, and 1C) near a monitor station. These households provide a representative selection of residences in the Torrance Airport area. Residences were initially selected to provide a sample of: (1) types of housing units - single family, small multifamily, large apartment complex, and (2) housing construction in terms of building materials and building sound transmission characteristics, i.e., number of windows and windows facing source. In the initial selection, households near any given noise monitoring station were paired for similarities in building construction in order to reduce variability in this parameter. However, due to constraints associated with subject recruitment, only two of the initial selections were available for participation in the survey. A larger sample size that could be employed for a full scale test would be expected to provide a valid measure of the effects of building construction type (i.e., noise reduction) in annoyance response.

2.2.2 Subject Recruitment

Recruitment of subjects was originally intended to be in two phases. Initial contact was to establish the presence of a willing subject at several homes near the airport remote monitoring stations. During the initial contact, preliminary information regarding the suitability of the subject would be obtained in addition to a brief indication of the subject's susceptibility to noise in the community via a short questionnaire. The results of these contacts were to be compiled and, from several potential homes near each monitor site, two subjects would then be selected. These two subjects were to have performed slightly different tasks during the course of the week-long experiment. However, it was decided before recruitment was initiated to utilize a single procedure to minimize confusion.

The final recruitment procedure was based upon the original plan, with the exception that willing subjects were accepted for the experiment as soon as found. It must again be emphasized at this point that the goal of the program was to evaluate methods for measurement and analysis of aircraft noise and the associated human response. Consequently, conventional respondent selection and sampling techniques more suited to large scale surveys were not necessarily adhered to.

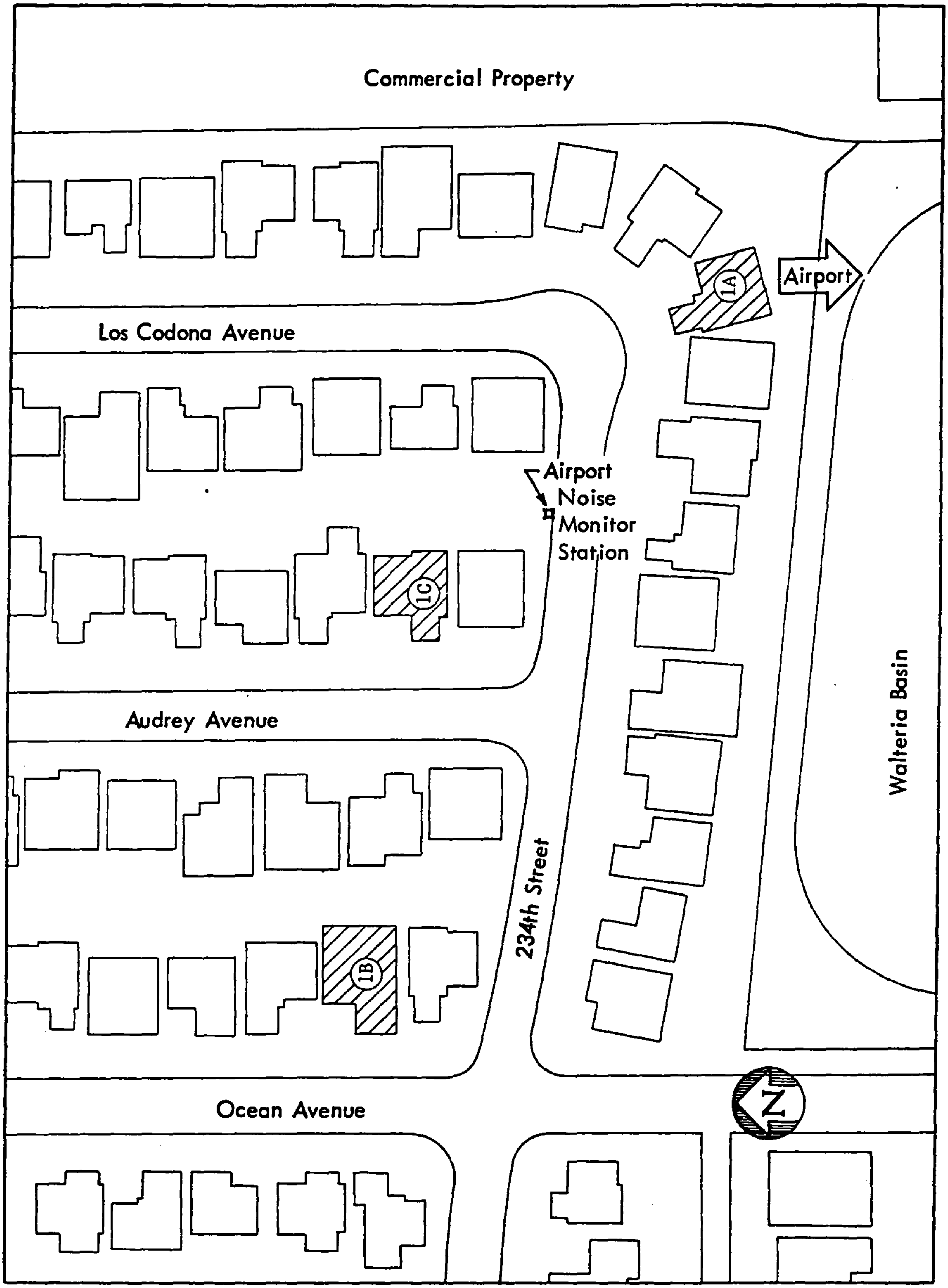


Figure 6. Location of Residential Locations Near Airport Noise Monitoring Station 1

Recruitment thus followed the outline below:

The recruiter first -

- o Established that the home was reasonably close (less than 300 m distance) from the remote monitor terminal.
- o Established that the resident was not a chronic noise complainant (from City records).

Candidate residences fulfilling these requirements were then visited and the recruitment process was initiated. The interviewer:

- o Identified himself and presented his business card.
- o Determined by observation that the potential subject was of sound mind with normal hearing, was physically mobile, and over 18 years of age.
- o Determined that the potential subject was the dwelling resident.
- o Briefly explained the program, e.g., the sound level would be recorded in the home to compare with outside levels from the Airport system.
- o Mentioned the experiment duration (5 to 6 days).
- o Mentioned the minimal time commitment to the experiment.
- o Mentioned the $50 payment for subject efforts and minor inconvenience.

If the potential subject seemed willing to progress further with the discussion, the interviewer:

- o Administered the recruitment instrument contained in Appendix A.
- o Explained in more detail the experiment and the task required.
- o Confirmed that the potential subject was willing to conduct the experiment.

At this stage, if the resident was still willing to proceed and all the recruitment requirements had been fulfilled, he was given the letter contained at the end of Appendix A. He was then asked if the experiment could be started and the interior noise monitoring equipment be installed.

Response from the recruitment exercise was quite varied. In general, the recruiter was well-received, though in some areas there was difficulty in finding

residents at home and willing to participate in the experiment. In order to acquire cooperative subjects at the 18 homes, a total of 167 homes were visited. All visits were made by the same field engineer between the hours of 9 a.m. and 6 p.m. The recruitment instrument was presented to a total of 19 subjects. To the greatest extent possible, the method of presentation of the instrument was identical for each subject. Of course, some differences occurred due to varying responses and requests for clarification by subjects.

Results of the recruitment interview were registered in the spaces provided on each form. Later the results were combined and tabulated to allow presentation in a format which would allow rapid visualization of the results. Tables I(a) and I(b) provide a tabulation of the results of the recruitment interview with the 19 subjects who completed the interview. (Immediately following this recruitment process, subject 5 was dropped from the rest of the program.) As a supplement to the data shown in this table, the following comments on subject recruitment are appropriate:

- There were only a few homes where it was known that someone was home who would not come to the door.
- Although the field engineer was alone, there was very little reluctance by the residents to open the door to a stranger.
- A surprising number of subjects agreed to participate in the experiment without checking the authenticity of the interviewer's identification and without checking with their mate. However, two subjects phoned the company to check the interviewer's credentials after the experiment was started.
- There was virtually no reticence in answering recruitment questions.
- There was a variety of reasons for refusing to participate in the experiment, including: could not be bothered; somewhat interested but did not want to get involved; their mate would not approve; no reason, but stated they could not.

2.2.3 Subject Instruction

Each subject was instructed in the procedures to follow in filling out the daily Activity Log and Annoyance Diary - illustrated in Figure 7. This diary includes a six-point scale for self-evaluation of annoyance due to noise events. The

Table 1(a)

Results Obtained from the Subject Recruitment Interview for the First Ten Subjects

Question		Subject (Site)/Response									
		1(1A)	2(9A)	3(9B)	4(2A)	5(None)	6(2B)	7(5A)	8(5B)	9(1B)	10(1C)
A8. (At Home)		50-75%	50-75%	75-100%	50-75%	50-75%	50-75%	75-100%	75-100%	50-75%	75-100%
A9. (Hearing)		Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good
1. (Rate Area)		Good	Very Good	Good	Good	Very Good	Very Good	Good	Very Good	Very Good	Good
2. (Area Noise)		Noisy	Noisy	Noisy	Quiet	Quiet	Noisy	Noisy	Quiet	Noisy	Quiet
3. (Annoy. Time)	AM	No	No	No	No	No	Yes	No	Yes	No	No
	Aft.	No	No	No	Yes	Yes	Yes	Yes	No	Yes	No
	Eve.	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes
	Night.	No	No	No	No	No	No	No	No	No	No
4. (Activ. Inter.)	Sleep	No	No	No	No	No	No	Yes	No	No	Yes
	Talk/TV	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes
	Read	No	No	Yes	No	No	No	No	Yes	Yes	No
	Rest	No	No	No	No	No	No	No	No	Yes	Yes
	Outside	Yes	No	No	Yes	No	No	No	No	Yes	No
5. (Noise Health)		No	No	Yes	No	No	No	No	No	Maybe	No
6. (Noise Annoy.)		Med. Annoyed	A Little Annoyed	Med. Annoyed	A Little Annoyed	A Little Annoyed	Med. Annoyed	Med. Annoyed	A Little Annoyed	Med. Annoyed	Med. Annoyed
7. (Source Annoy.)	Veh.	A Little Annoyed	Not At All Annoyed	Cons. Annoyed	Cons. Annoyed	A Little Annoyed	Med. Annoyed	Highly Annoyed	Med. Annoyed	Med. Annoyed	Cons. Annoyed
	Sirens	Not At All Annoyed	Not At All Annoyed	Med. Annoyed	A Little Annoyed	Not At All Annoyed	Not At All Annoyed	Med. Annoyed	Highly Annoyed	A Little Annoyed	Not At All Annoyed
	Pets	Part. Annoyed	Not At All Annoyed	Med. Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Highly Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed
	Neigh.	Cons. Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Highly Annoyed	A Little Annoyed	Not At All Annoyed	A Little Annoyed
	Jets	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Cons. Annoyed	Trem. Annoyed	Highly Annoyed	Highly Annoyed
	GA A/C	Highly Annoyed	Not At All Annoyed	Highly Annoyed	Part. Annoyed	A Little Annoyed	Not At All Annoyed	A Little Annoyed	Highly Annoyed	Cons. Annoyed	Med. Annoyed
	Helicopt.	Not At All Annoyed	Not At All Annoyed	Highly Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	A Little Annoyed	A Little Annoyed	Not At All Annoyed	Med. Annoyed
	Yardwork	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed	Cons. Annoyed	A Little Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed
8. (Other Sources)		No	No	Yes	No	No	No	No	No	Yes	Yes
9. (Age)		41	60+	44	60	69	67	73	25	67	47
10. (School)		14	12	13	15	12	10	12	15	14	12
B1. (Sex) *		Female	Male	Female	Male	Female	Female	Male	Male	Male	Female
B2. (English) *		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
B3. (Hearing) *		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Indicates Interviewer's Observations

Table 1(b)

Results Obtained from the Subject Recruitment Interview for the Last Nine Subjects

Question			Subject (Site)/Response								
			11(7A)	12(7B)	13(6A)	14(6B)	15(3A)	16(3B)	17(8A)	18(8B)	19(4A)
A8.	(At Home)		25%	25%	25%	25%	50-75%	50-75%	50-75%	25%	50-75%
A9.	(Hearing)		Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Good	Good
1.	(Rate Area)		Very Good	Good	Very Good	Good	Good	Very Good	Good	Very Good	Average
2.	(Area Noise)		Quiet	Quiet	Noisy	Noisy	Noisy	Very Quiet	Quiet	Noisy	Quiet
3.	(Annoy. Time)	AM	No	No	No	Yes	No	No	No	Yes	No
		Aft.	Yes	No	Yes	No	No	No	No	Yes	Yes
		Eve.	No	No	Yes	Yes	Yes	No	Yes	No	No
		Night	Yes	No	No	No	No	No	Yes	No	No
4.	(Activ. Inter.)	Sleep	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
		Talk/TV	No	No	Yes	Yes	Yes	No	Yes	Yes	No
		Read	Yes	No	No	Yes	No	No	Yes	Yes	No
		Rest	Yes	No	Yes	Yes	No	No	Yes	Yes	No
		Outside	No	No	No	Yes	No	No	No	Yes	No
5.	(Noise Health)		Maybe	Yes	Maybe	Yes	No	Yes	Yes	Maybe	No
6.	(Noise Annoy.)		Med. Annoyed	Not At All Annoyed	Highly Annoyed	Cons. Annoyed	Cons. Annoyed	A Little Annoyed	Cons. Annoyed	Cons. Annoyed	A Little Annoyed
7.	(Source Annoy.)	Veh.	A Little Annoyed	A Little Annoyed	Med. Annoyed	Highly Annoyed	Trem. Annoyed	A Little Annoyed	Cons. Annoyed	Not At All Annoyed	A Little Annoyed
		Sirens	Med. Annoyed	Not At All Annoyed	Not At All Annoyed	Med. Annoyed	Med. Annoyed	Med. Annoyed	A Little Annoyed	Not At All Annoyed	Part. Annoyed
		Pets	Trem. Annoyed	Not At All Annoyed	Not At All Annoyed	A Little Annoyed	Not At All Annoyed	Highly Annoyed	Not At All Annoyed	A Little Annoyed	Cons. Annoyed
		Neigh.	Med. Annoyed	Not At All Annoyed	Highly Annoyed	Part. Annoyed	Part. Annoyed	A Little Annoyed	Not At All Annoyed	Not At All Annoyed	Not At All Annoyed
		Jets	Highly Annoyed	Not At All Annoyed	Highly Annoyed	Trem. Annoyed	Not At All Annoyed	A Little Annoyed	Not At All Annoyed	Not At All Annoyed	Part. Annoyed
		GA A/C	Cons. Annoyed	A Little Annoyed	Highly Annoyed	Cons. Annoyed	A Little Annoyed	A Little Annoyed	Not At All Annoyed	Not At All Annoyed	Part. Annoyed
		Helicopt.	Cons. Annoyed	Not At All Annoyed	Med. Annoyed	Highly Annoyed	Not At All Annoyed	A Little Annoyed	Not At All Annoyed	Cons. Annoyed	Not At All Annoyed
		Yardwork	Trem. Annoyed	Cons. Annoyed	Not At All Annoyed	A Little Annoyed	Cons. Annoyed	Med. Annoyed	Not at All Annoyed	Not At All Annoyed	Not At All Annoyed
8.	(Other Sources)		Yes	Yes	No	Yes	No	No	Yes	No	No
9.	(Age)		33	29	60	35	36	42	34	53	68
10.	(School)		14	17	11	18	16	12	16	13	10
B1.	(Sex) *		Female	Female	Female	Male	Male	Female	Female	Female	Male
B2.	(English) *		Good	Fair	Good	Good	Good	Good	Good	Good	Good
B3.	(Hearing) *		Good	Good	Good	Good	Good	Good	Good	Good	Good

*Indicates Interviewer's Observations

Daily Record of Activity and Annoyance

Residence HOME ADDRESS

Date 9-9-80

Activity/Location Log

Time	Main Activity: Quiet	TV/Radio	Work/Chores	Converse	Sleeping	Other	Main Location: Family Room	Living Room	Kitchen	Bedroom 1	Bedroom 2	Other	Outside Home	Not Home	Windows Open
Mid. - 1 AM					✓					✓					
1 AM - 2 AM					✓					✓					
2 AM - 3 AM					✓					✓					
3 - 4					✓					✓					
4 - 5					✓					✓					
5 - 6					✓					✓					
6 - 7					✓					✓					
7 - 8			✓						✓						
8 - 9			✓					✓							
9 - 10															
10 - 11															
11 - Noon	✓							✓							
Noon - 1 PM			✓						✓						
1 PM - 2 PM		✓						✓							✓
2 - 3		✓						✓							✓
3 - 4	✓							✓							✓
4 - 5	✓							✓							✓
5 - 6			✓										✓		✓
6 - 7			✓						✓						✓
7 - 8				✓					✓						✓
8 - 9		✓						✓							✓
9 - 10		✓						✓							✓
10 - 11		✓						✓							
11 - Mid.					✓					✓					

Quiet Activities – Reading, Writing, Studying
Converse Includes Talking and Eating
Other Includes Recreation
Windows in Microphone Room only

Monitor in the Living Room

Annoyance Diary

	Time (AM-PM)	Noise Source: Aircraft	Vehicle	Other Exterior	Interior	Annoyed: Tremendously	Highly	Considerably	Medium	Partially	A Little
1.	8:32A	✓							✓		
2.	8:37A	✓								✓	
3.	8:45A		✓							✓	
4.	1:24P			✓				✓			
5.	1:27P	✓							✓		
6.	1:52P				✓			✓			
7.	9:11P	✓							✓		
8.	9:30P	✓							✓		
9.											
10.											
11.											
12.											
13.											
14.											
15.											
16.											
17.											
18.											
19.											
20.											
21.											
22.											
23.											
24.											

Check only one noise source for each entry.

Figure 7. Example of the Subject Activity Log and Diary

descriptors used in this scale are based on a Thurstone Scaling Study[2] with one exception: the word "highly" replaces the original word "greatly." As in the original scale, the six levels of annoyance are given integer numerical values. Instructions given to the subject were as follows:

- The activity/location log could be filled out two or three times a day since they were to note only their main activity and location each hour of the day and night. (This part of the data sheet was modified three times during the course of the pilot test to improve clarity and add desirable features.)
- Add a check mark to the "Windows Open" column if outside windows or doors of the test room were open.
- During the time the subjects were in the test room or area where the interior noise measurements were being made, they were instructed to note the time whenever they heard an annoying sound and to make an entry in the Annoyance Diary. In some cases the test room encompassed several rooms separated by low dividers or wide openings. This task confused some subjects. The dividing bar between the log and diary was then added with the footnote shown in Figure 7, in order to eliminate the entry of one event per hour as practiced by one or two subjects. An example diary sheet was also provided to minimize confusion in this task. It was stressed to the subject that entries were to be made only when they were in the test room.
- The log and diary were to be maintained daily for the 5- to 6-day duration of the experiment.

In all cases, the Wyle digital recording system to be placed in the home for interior noise measurements was described to the subject, stressing that speech would not be intelligible on playback, since the system recorded only the level of any sound. The small electrical power drain was also mentioned and the recording time (over 40 hours) was discussed in light of the need to visit the residence and change tapes.

When the subject appeared to understand the tasks required, the interviewer made an appointment to return in 1 to 2 days to change the tape on the recorder. These return visits were also intended to reinforce the subject's commitment to participate in the experiment and to clarify any problems encountered with the log/diary.

2.2.4 Equipment Set-up

Interior Measurements

At most locations, installation of recording equipment directly followed recruitment. Tasks performed by the interviewer were as follows:

- o Select the room in the home occupied by the subject during most of his waking hours.
- o Install a digital recorder at a location out of the subject's way, and close to a power outlet.
- o Place the microphone in an inconspicuous location away from dominant indoor sources if possible, and close to the area most occupied by the subject, if possible. The microphone was usually on a stand approximately 3 ft above the floor and 6 to 12 inches from a room wall with the windscreen in place to maximize protection.
- o Place the digital clock at a position easily visible from most of the test room area, and set it to the correct time.
- o Record a calibration level on tape and start the digital recording system, noting the start time on the cassette label. Synchronize this clock with the Torrance Airport noise monitor system.
- o Obtain site specific information including: (1) orientation of home with respect to the airport monitor, (2) rough floor plan of the test room area within the subject's home - including location of monitor microphone, (3) locations and sizes of doors and windows, and (4) types of obvious noise sources within the home - hi-fi, TV, etc. Figure 6 is an example of the diagrams of site locations in relation to one of the airport noise monitor microphones.

Due to the open architecture typical of many California residences, the digital recorder often covered more than one room (this happened at 11 sites). At most sites, the living room or family room and the kitchen comprised the test rooms. At one site (5B), the test room was the bedroom and, at another, (6B), it was a workshop adjoining a garage. Appendix C provides a tabular listing of the components in the Wyle measurement system used for indoor measurements and the Torrance Airport monitor system used for exterior measurements.

Exterior Measurements

The exterior noise environment near each residence was measured with the existing sytem utilized by Torrance Airport for monitoring noise produced by general aviation aircraft using the airport (see Appendix C). This is a computer-based system which processes data from nine permanent monitoring sites, located at strategic points on runway approach, takeoff, sideline, and sensitive locations in the adjacent community (see Figure 3 for monitor locations and Figure 8 for typical data printout of aircraft noise). It is utilized to (1) monitor the effectiveness of noise abatement procedures, (2) evaluate compliance with single event noise limits specified by the Torrance Noise Ordinance, and (3) verify noise complaint data by local residents.

Data are printed out daily in terms of significant composite and single event noise metrics. In addition, this system prints out single event "violations;" that is, single events which exceed the limits set forth in the Torrance Airport Noise Ordinance. Data computed for these aircraft include the maximum A-weighted sound levels and the SENEL (Single Event Noise Exposure Level) values.* Airport personnel compare the single event violations from the system with tower/aircraft communications to identify the aircraft. Only a few such violations occurred during the pilot study, and these have not been included in the following analyses.

2.3 Data Acquisition

Data acquisition commenced at each subject's home immediately upon installation of the indoor recording system and completion of a site description. During the course of the measurements at each site, data were recorded by the subject on the forms illustrated in Figure 7. These data produced information relative to the subject's activity and location for each hour of the day, and also their relative annoyance due to noise events. Due to confusion on the part of some subjects, the number of hours registered for each activity/hour may exceed the number of test hours. Regardless, it is believed these data represent the approximate distribution of a subject's activities and locations for the duration of the experiment. The validity of these data was estimated by the field engineer in order to provide guidance in the subsequent data analysis.

*The SENEL is the sound exposure level (SEL) during the time the aircraft noise level exceeds a specified threshold noise level. For purposes of this study, SENEL and SEL can be considered essentially equivalent.

P 419 FRI 09-12-80 ← Date

1200 HOURLY REPORT ← Hour of Report

PATTERN	WIND	TEMP	R HUM	D PT	PRESS	D ALT
WEST	SE 3	70	80	66	29.99	652 ← Weather

Noise Data

RMS	HNL	HNLA	HNLC	THRESH	MINS	ERRS	MNTXX	L1	L10	L50	L90	L99
1	60	57	57	-62	60	0	0	73	60	51	47	46
2	54	45	53	62	60	0	0	60	56	51	49	47
3	0	0	0	62	0	0	0	40	40	40	40	40
4	54	0	54	62	60	0	0	63	56	51	48	46
5	57	50	56	62	60	0	0	67	59	53	49	46
6	54	0	54	62	59	0	0	63	57	51	49	46
7	51	0	51	62	60	0	0	59	53	50	47	46
8	53	0	53	62	60	0	0	60	56	51	49	46
9	55	51	52	62	60	0	0	66	54	50	47	46
10	61	60	55	70	60	0	0	74	55	49	46	46
11	54	49	53	70	60	0	0	61	54	50	47	46

$

Single Event Noise Exceedences

JDAY	TIME	RMS	MAX	SENEL	LIMIT	DUR	WIND	A/D	THRESH
256	1208:00	1	68	76	88	11.5	063/03	D	-62
$									
256	1207:38	10	81	87	100	10.0	063/03	D	-62
$									
256	1222:45	1	79	85	88	14.0	353/05	D	-62
$									
256	1222:30	10	77	83	100	7.0	354/05	D	-62
$									
256	1225:16	1	76	83	88	18.0	339/04	D	-62
$									
256	1224:59	10	78	85	100	9.0	339/04	D	-62
$									
256	1225:53	1	86*	91*	88	19.5	342/03	D	-62 — CESSNA
$									
256	1225:37	10	86	89	100	7.5	342/03	D	-62
$									

	TIME	RMS	250 HZ MAX	250 HZ SENEL	1 KHZ MAX	1 KHZ SENEL
CAL CHK	1226:08	1	0	0.0	115	125.3

$

JDAY	TIME	RMS	MAX	SENEL	LIMIT	DUR	WIND	A/D	THRESH
256	1229:26	1	78	88	88	50.5	075/00	D	-62

P 440 SAT 09-13-80

NOISE LEVEL EXCEEDANCE SUMMARY FOR FRI 09-12-80

Daily Summary of Single Event Noise Exceedences

JDAY	TIME	RMS	MAX	SENEL	LIMIT	DUR	WIND	A/D
256	0020:54	1	77*	85*	82	17.5	311/00	D
256	0944:44	6	90*	98*	88	20.0	111/02	A
256	1027:31	1	84*	89*	88	18.5	134/04	D
256	1056:30	9	84*	89*	88	10.5	142/04	D
256	1150:55	1	80	89*	88	28.0	063/01	D
256	1225:53	1	86*	91*	88	19.5	342/03	D — A/C-CESSNA
256	1234:44	1	83*	90*	88	23.5	060/03	D
256	1318:08	1	102*	105*	88	25.0	283/09	D
256	1351:41	1	83*	90*	88	29.0	304/11	D
256	1501:12	1	86*	92*	88	34.0	330/07	D
256	1510:33	9	82	89*	88	12.0	233/07	D
256	1511:29	5	83*	87	82	7.5	281/05	A
256	1511:32	1	82	89*	88	36.5	291/08	D
256	1534:05	9	85*	91*	88	13.0	301/11	D
256	1648:07	5	85*	89*	88	7.5	269/11	A
256	1718:35	5	83*	86	82	5.5	280/13	A
256	1739:17	1	83*	88	82	16.0	285/07	D
256	1944:43	5	85*	89*	88	8.5	266/05	A
256	2255:45	5	88*	91*	88	11.5	300/00	A

Figure 8. Data Printout from Torrance Airport Noise Monitoring System. Written notations are identification of violators by Torrance Airport personnel.

Each test ran for a nominal period of 5 days; it was necessary for the engineer to visit the home at least three times during this period to change tapes in the digital noise recorder. During this period, the Wyle engineer provided clarification to the subjects on how to record activity/response data. He also made his own observations on obvious characteristics of the noise environment and the attitude of the subject toward the project. It was suspected early in the program, and later confirmed through a review of test results, that subject response would be highly individualistic. Notes were made of individual differences which could be useful when the data for all sites were combined for statistical analysis.

In entering annoying aircraft events in the diaries, the subjects showed variations in interpretation of the instructions. Table 2 contains a summary of the annoying noise events noted at each site and the type of source identified. The range in the number of events noted by each subject is large, from three at Site 2A to 344 at Site 9A. This large range is not due to variations in the number of hours spent in the test rooms so much as to variations in the numbers of diary entries per hour, as shown in Figure 9. The relation between diary entries and noise levels will be discussed in the next section. In addition, some subjects clearly were unable to note each and every annoying aircraft. For example, one subject (at Site 1A) explained in a handwritten note appended to the diary that during one afternoon there were too many aircraft of medium to considerable annoyance, so the subject was not logging any of them. Another subject (at Site 9B) noted only aircraft events occurring every hour on the hour for two evenings (this was not due to the previously mentioned confusion regarding the diary format).

Data reduction of the noise measurements was performed in two stages. The first stage was the calculation of statistical noise levels such as the L_0, L_{10}, L_{90}, L_{eq}, and L_{dn}. For the outdoor noise, this analysis was performed by the airport noise monitoring system, while for the indoor noise, the digital tape recordings for the Wyle system were analyzed with a minicomputer. Figure 10 shows an example of the data output from the interior noise measurement system.

The second stage was the identification of aircraft noise events on the stripchart recordings produced by the indoor measurement system (Figure 10). This identification was made by correlating times on the stripcharts with the times of diary entries for annoying aircraft.

Table 2

Summary of Annoying Events Registered by Subjects During the Study

Site	Number of Events Noted by Noise Source				
	Aircraft	Vehicle	Other Exterior	Interior	Total
1A	35	0	0	5	40
1B	109	0	1	0	110
1C	67	2	0	0	69
2A	2	1	0	0	3
2B	25	15	7	0	47
3A	3	3	4	2	12
3B	5	0	2	0	7
4A	76	0	0	0	76
5A	3	1	0	0	4
5B	0	2	0	5	7
6A	37	4	0	0	41
6B	1	1	8	0	10
7A	1	1	8	10	20
7B	9	1	3	5	18
8A	10	0	0	0	10
8B	9	0	0	0	9
9A	315	27	2	0	344
9B	75	9	2	7	93

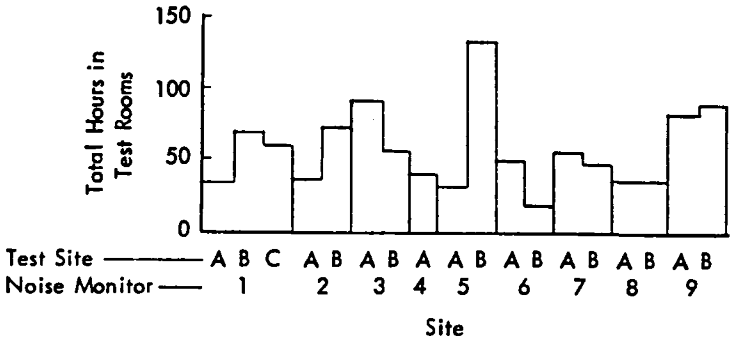


Figure 9(a). Total Number of Hours Test Rooms Were Occupied

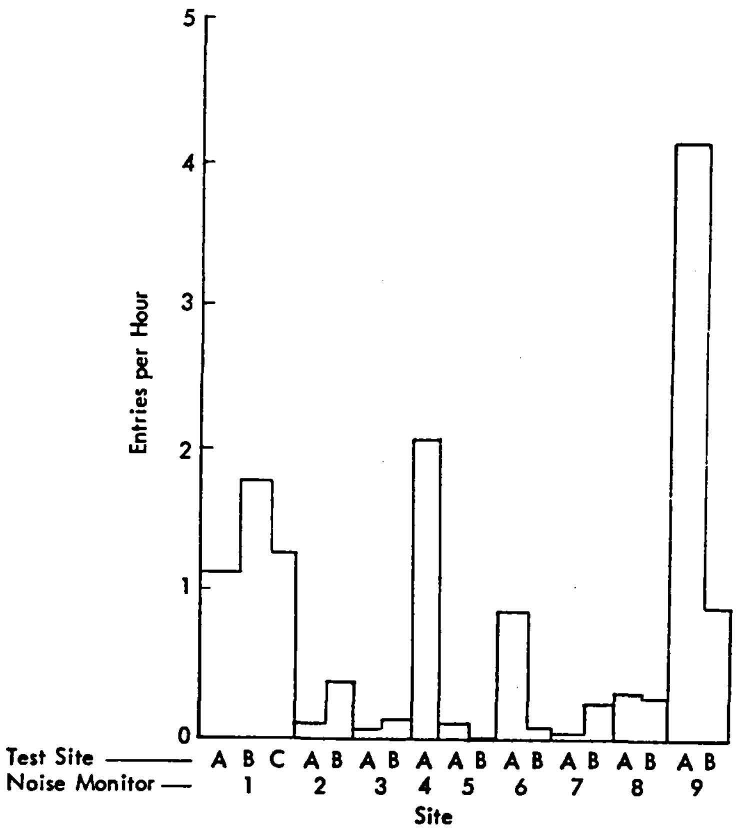


Figure 9(b). Average Number of Diary Entries per Hour

The remainder of this section provides tabular and graphic information describing the inside and outside noise environments measured, and the relationships of these environments to subject response and activity. The following data are presented:

Figure 10 - Example of Raw Data Output from Interior Noise Measurement System

Figure 11 - Example of Interior and Exterior Hourly Noise Levels (L_{eq} and L_1) at Site 9.

Table 3 - Example of Site and Subject Test Data from Site 1A and Subject 1. This is a summary of annoyance and response data for Site 1A. Appendix B contains similar data for all test sites. In these tables, single event noise data for aircraft events only in terms of average maximum levels are listed. These levels are designated "Average A/C Event Level" in the table headings. L_{eq} and L_{max} values (including nonaircraft events) are shown for those hours the subject was in the test room. Data on "L_{max} outside" is not complete in these tables, as the process time required for extracting these data from the airport records was beyond the available resources for this program. Maximum inside and outside measurements represent the maximum A-weighted levels extracted from histograms of the respective noise environments.

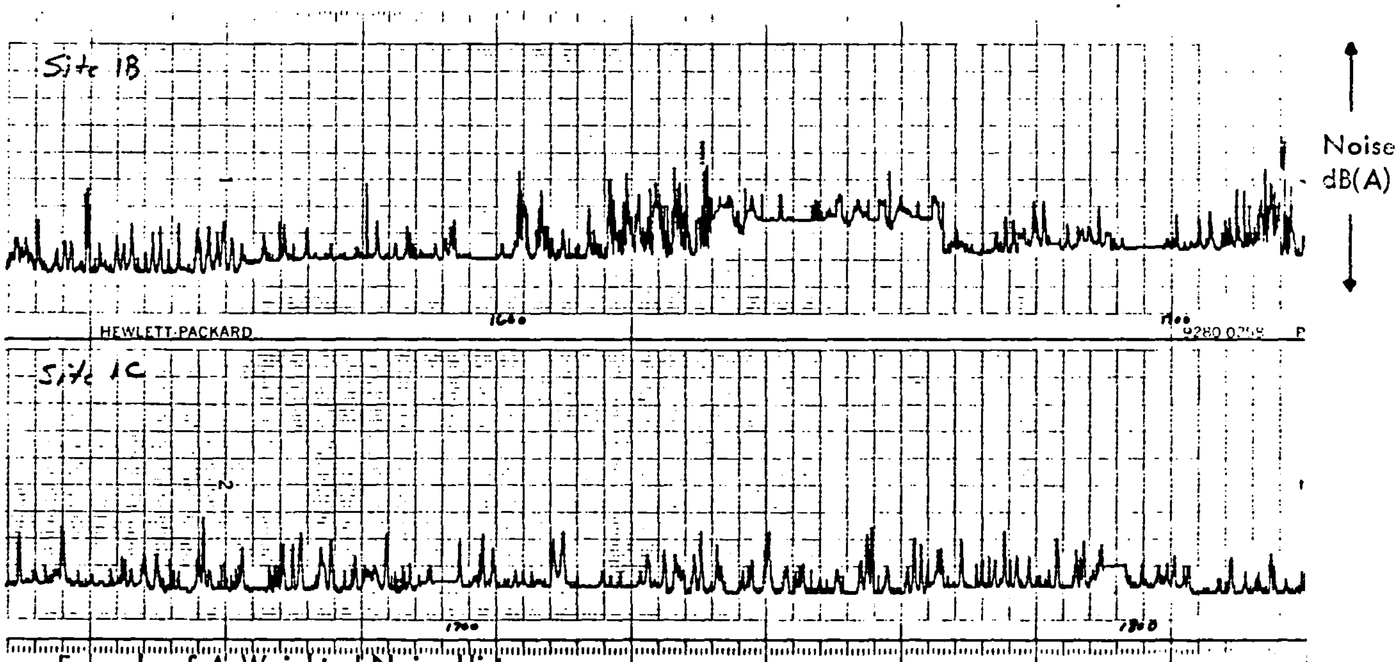
Table 4 - Data Summary of Subject Recruitment, Data Recorded, Subject Annoyance, and Site Noise Levels. This table provides a comprehensive summary of noise environment and subject response data obtained in the program.

Table 5 - L_{dn} at Airport Sites During Measurement Periods at the Residential Locations. The L_{dn} values are calculated using data from the Torrance Airport noise monitor system locations which provided all outside noise data measured in the program (see Figure 3 for site locations).

TAPE TORR-35
SITE 1C 23328 AUDREY
0820 ON 9-12 TO 1645 ON 9-13

Hourly Metrics Printed Out After Test

HOUR		LEQ	L99	L90	L50	L10	L1	L0
			DB LEVELS					
820	900	57.6	41	42	53	61	68	73
900	1000	59	36	38	45	63	69	78
1000	1100	59	36	40	55	63	68	73
1100	1200	47.2	40	40	41	45	59	73
1200	1300	41	36	36	36	41	52	63
1300	1400	44	36	40	41	46	54	67
1400	1500	44.1	36	37	41	47	53	59
1500	1600	45.3	36	37	41	47	55	68
1600	1700	55.5	41	43	50	59	64	75
1700	1800	64.5	41	43	50	64	73	95
1800	1900	64.6	43	47	57	68	74	90
1900	2000	66.7	40	40	42	66	78	92
2000	2100	77.7	36	37	41	66	94	95
2100	2200	62.2	40	41	52	66	73	82
2200	2300	53.1	36	40	41	49	66	77
2300	0	52.1	36	36	41	55	64	73
0	100	41	40	41	41	41	41	43
100	200	41	40	40	41	41	42	52
200	300	40.1	36	36	40	41	41	42
300	400	36.6	35	36	36	36	40	56
400	500	40.3	39	40	40	41	41	46
500	600	39.4	36	36	40	41	41	46
600	700	37.3	35	36	36	40	40	51
700	800	41.5	36	36	40	41	45	70
800	900	60.7	41	41	56	63	71	85
900	1000	58.9	37	41	46	63	69	79
1000	1100	38.7	36	36	37	40	46	55
1100	1200	42.2	36	40	41	43	50	53
1200	1300	43	36	37	41	43	51	62
1300	1400	42.1	36	37	38	42	53	64
1400	1500	42.1	41	41	41	43	48	56
1500	1600	49.7	36	37	40	48	63	73
1600	1645	55.3	36	38	42	50	63	82



Example of A-Weighted Noise Histograms

Figure 10. Data Printout for Digital Recording System Used to Record Indoor Noise Environment

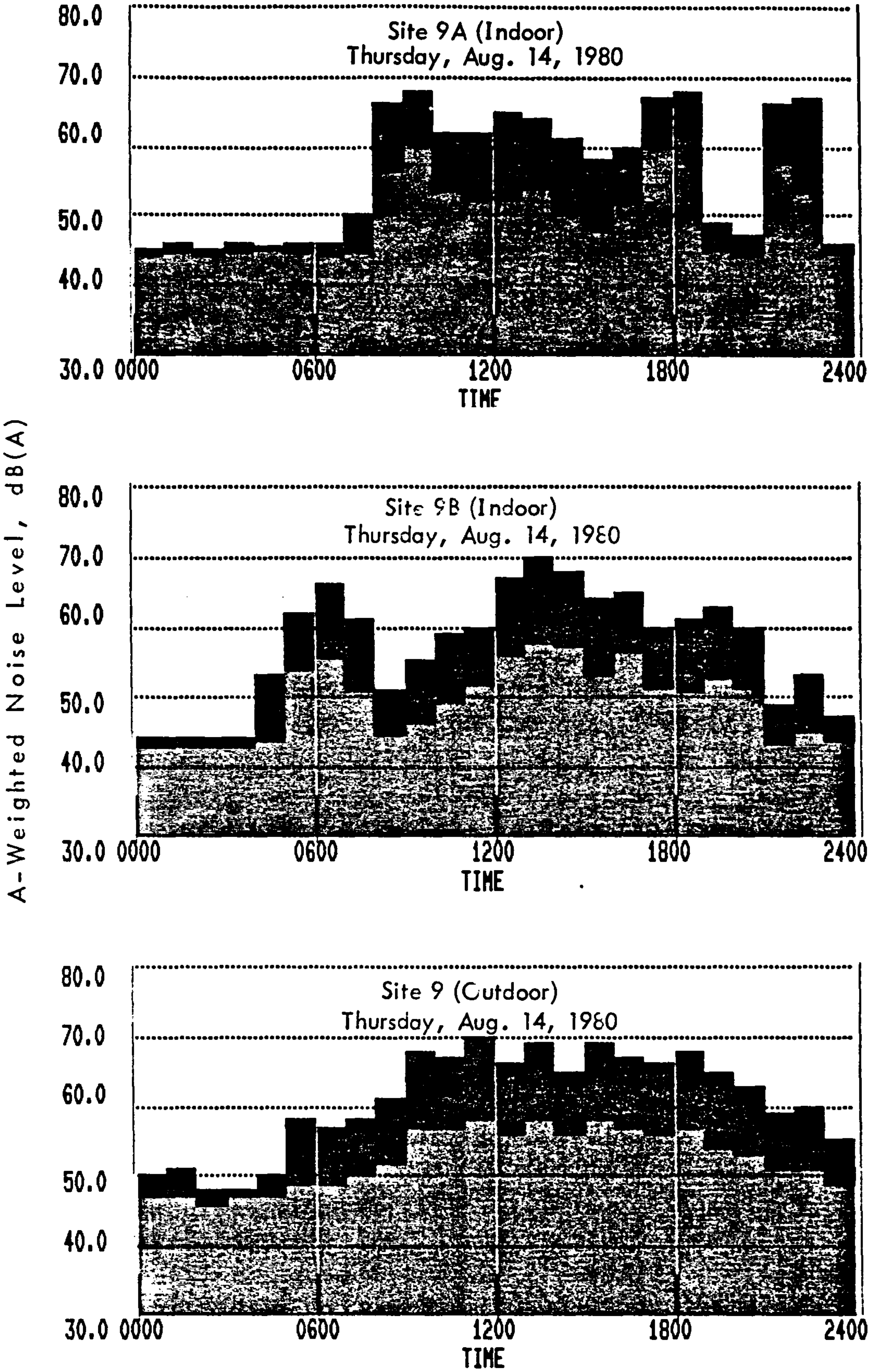


Figure 11. Example of Indoor and Outdoor Hourly Noise Levels (L_{eq} and L_1) at Site 9.

Table 3

Example of Site and Subject Test Data

Summary of Test Data at Site 1A for Subject 1
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C Event Level(b)		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Wed. 8-6-80	1800-2200	2					58.2	60.4	79	-
	2200-0700									
Thurs. 8-7-80	0700-1200									
	1200-1800	3					60.8	63.8	93	80
	1800-2200	3	7	1.6	55.0	71.0	54.4	60.2	76	83
	2200-0700	1					53.2	54.0	62	75
Fri. 8-8-80	0700-1200	1	11	3.0	64.0	74.0	69.7	66.0	84	85
	1200-1800	1	3	3.0	65.0	77.0	61.8	63.0	81	80
	1800-2200	3	4	3.8	62.0	76.0	62.6	59.3	86	79
	2200-0700	2					62.5	55.0	88	72
Sat. 8-9-80	0700-1200	1	3	4.0	63.0	76.0	60.0	66.0	76	82
	1200-1800	2					-	64.1	-	83
	1800-2200	3	6	3.5	-	77.0	59.5	57.1	82	82
	2200-0700	2	1	2.0	-	70.0	49.4	54.4	72	77
Sun. 8-10-80	0700-1200									
	1200-1800									
	1800-2200	3					46.6	55.8	65	80
	2200-0700	2					45.1	53.5	47	77
Mon. 8-11-80	0700-1200									
	1200-1800									
	1800-2200	3					56.6	59.3	79	83
	2200-0700									
Tues. 8-12-80	0700-1200									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table 4

Data Summary of Subject Recruitment, Data Recorded, Subject Annoyance, and Site Noise Levels

Airport Monitoring Sites	1			2		3		4	5		6		7		8		9		Totals 9
Home Sites Used for Measurements	1A	1B	1C	2A	2B	3A	3B	4A	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	18
Houses Visited to Acquire Sites	4	2	3	18	10	9	15	46	1	13	6	8	9	11	3	2	6	1	167
Age of Subject	41	67	47	60	67	36	42	68	73	25	60	35	33	29	34	53	60+	44	—
Total Test Hours	138	145	172	133	140	140	139	114	128	168	142	49	138	138	138	137	140	140	2439
Hours of Indoor Data Recorded	126	134	172	141	140	138	136	113	127	156	140	71	138	138	121	133	140	135	2399
Hours Spent in the Test Room (TR)	31	62	54	34	65	81	51	37	27	116	43	17	53	43	33	33	76	82	938
Number of Annoying Aircraft Events	35	109	67	2	25	3	5	76	3	0	37	1	1	9	10	9	315	75	782
Average Annoyance Rating[(1)]	2.95	2.66	2.83	3.0	2.16	2.0	1.2	3.1	4.0	0	3.04	5.0	5.0	3.22	1.49	4.03	2.29	3.42	2.86
Average Hourly Inside L_{eq} While TR Occupied	55.5	55.8	59.4	48.7	52.0	57.7	57.8	49.0	52.2	56.2	53.8	51.4	56.3	59.6	55.4	52.1	54.5	52.0	—
Average Hourly Outside L_{eq} While TR Occupied	60.7	61.6	63.1	57.4	58.0				58.8	56.7	57.8	58.8	55.6	55.5			56.2	56.7	—
Outside Average Daily L_{dn} During Measurement Period	62.4	61.9		58.1		57.8		60.3	59.4		58.8		56.8		58.8		57.0		—

[(1)] The average annoyance rating is the arithmetic average of the annoyance ratings given by the respondent to each single (aircraft and nonaircraft) event.

Table 5

L_{dn} at Airport Sites During Measurement Periods at the Residential Locations

Site	Measurement Period	Daily L_{dn} Values for Day, dB								Energy Average L_{dn}
		1	2	3	4	5	6	7	8	
1A	Wednesday, 8-6-80 to 8-12-80	63	62	62	64	62	62	61		62.4
1B & 1C	Tuesday, 9-9-80 to 9-16-80	61	62	60	64	64	58	61	62	61.9
2A & 2B	Tuesday, 8-19-80 to 8-25-80	58	58	58	59	57	57	59		58.1
3A & 3B	Tuesday, 9-30-80 to 10-6-80	62	57		56	56	56	56		57.8
4A	Monday, 10-13-80 to 10-18-80		59	60						60.3
5A & 5B	Monday, 8-25-80 to 9-1-80	60	60	59	60	55	60	61	58	59.4
6A & 6B	Tuesday 9-23-80 to 9-29-80	59	59	57	59	59	59	59		58.8
7A & 7B	Tuesday, 9-16-80 to 9-22-80	57	58	57	57	56	55	57		56.8
8A & 8B	Tuesday, 10-7-80 to 10-13-80		56	62	58	57	57			58.8
9A & 9B	Wednesday, 8-13-80 to 8-19-80	56	57	57	57	58	57	57		57.0

2.4 Data Analysis

A basic question addressed in this program was to evaluate a method for exploring whether human response to aircraft noise can be closely related to the intrusiveness of aircraft noise above indoor noise levels. Clearly, this is closely related to asking whether exposure to aircraft noise is disturbing to individuals. Thus, the primary independent variable is the noise level associated with an aircraft, as experienced within a subject's house, and the dependent variable is the annoyance reaction of people exposed to aircraft noise. This section will first present general observations of the noise measurements and annoyance diary entries, and then will explore a few of the many possible correlations between these two sets of data.

In these analyses, two households will be singled out as special cases. The first, Site 5B, is where the test room was the bedroom. It is the only location where no annoying events were marked in the diary. The hours during which this subject occupied the test room usually coincided with the nighttime Torrance Airport curfew on departures. This precludes meaningful comparison with the other respondents, so Site 5B will be omitted from the analyses. The other special case is Site 9A. This subject alone recorded 40 percent of all the diary entries in the pilot study; to avoid giving unfair weight to this respondent's data, Site 9A was analyzed separately from the other sites. Results of data analyses for 9A do not differ significantly from the overall data trends and will be omitted from the following presentation.

2.4.1 Noise Measurements

To put the aircraft noise measurements in perspective, some attention must be first given to indoor ambient sound levels. As previously discussed, all annoyance notations were made in the vicinity of the indoor noise digital recorder. Usually, this location included one or two rooms such as the living room or family room and the kitchen.

The households included in the pilot study may be described as typical indoor residential noise environments with hourly L_{eq} levels around 55 dB(A). The kitchen, a major source of noise, was included among the test rooms at the noisiest sites. For all sites excluding 5B and 9A, hourly L_0 (peak) and L_{10} sound levels averaged 73 dB(A) and 56 dB(A), respectively; for Site 9A, these levels averaged 72 dB(A) and 56 dB(A), respectively.

Against this background noise environment, the noise due to passing aircraft was <u>not</u> a dominating effect. In fact, the average indoor maximum sound level due

to aircraft was only 61 dB(A) for all sites. Indoor maximum sound levels due to aircraft were about 12 dB below maximum levels due to other sources. Figure 12 presents the distributions of hourly sound levels for the indoor environments during hours when annoyance was noted in the diaries. Because aircraft noise is not a major determining factor of the indoor acoustic environments, the hourly statistical levels L_0 and L_{10} were practically useless in discriminating indoor sound levels of the general aviation aircraft; the only way to accurately extract noise due to aircraft from the digital recorder data is to correlate sound level peaks in the stripchart recordings with known times of flyovers. This procedure involves considerable labor and risk of error. These problems will be discussed further in Section 2.4.3.

2.4.2 Annoyance Response

In general, the annoyance response of all the subjects in the pilot study can be characterized as moderate; on the six-point scale of annoyance used in the diaries, the overall average degree of annoyance was 2.9 (3 = medium annoyed). As Table 2 shows, there was considerable variation among subjects in their respective average annoyance ratings. However, among those subjects who made a large number of entries (i.e., larger than more than 20 entries), these averages tend toward the overall average.

An interesting comparison can be made between each subject's average annoyance rating and that subject's general attitude toward general aviation noise (as recorded in the Recruitment Instrument, Appendix A). Figure 13 plots these two metrics of annoyance against each other; the dashed diagonal line corresponds to agreement between the two metrics. Clearly, there is little correlation between these two measures of annoyance. However, most of the subjects were, on the average, more annoyed by individual aircraft events than indicated by their general attitude toward aircraft noise. For example, the subject at Site 8B, who claimed to be "not at all" annoyed by general aviation noise, rated nine aircraft as "considerably annoying" (average rating). The major exception is the subject at Site 5B, who claimed to be highly annoyed by general aviation noise but who did not record a single annoying event in the diary. For reasons already discussed, this subject is considered a special case and is excluded from the study.

2.4.3 Correlating Noise and Annoyance

As stated earlier, the noises with the highest A-weighted noise levels and, presumably loudest, in the test rooms had little to do with aircraft. It is not

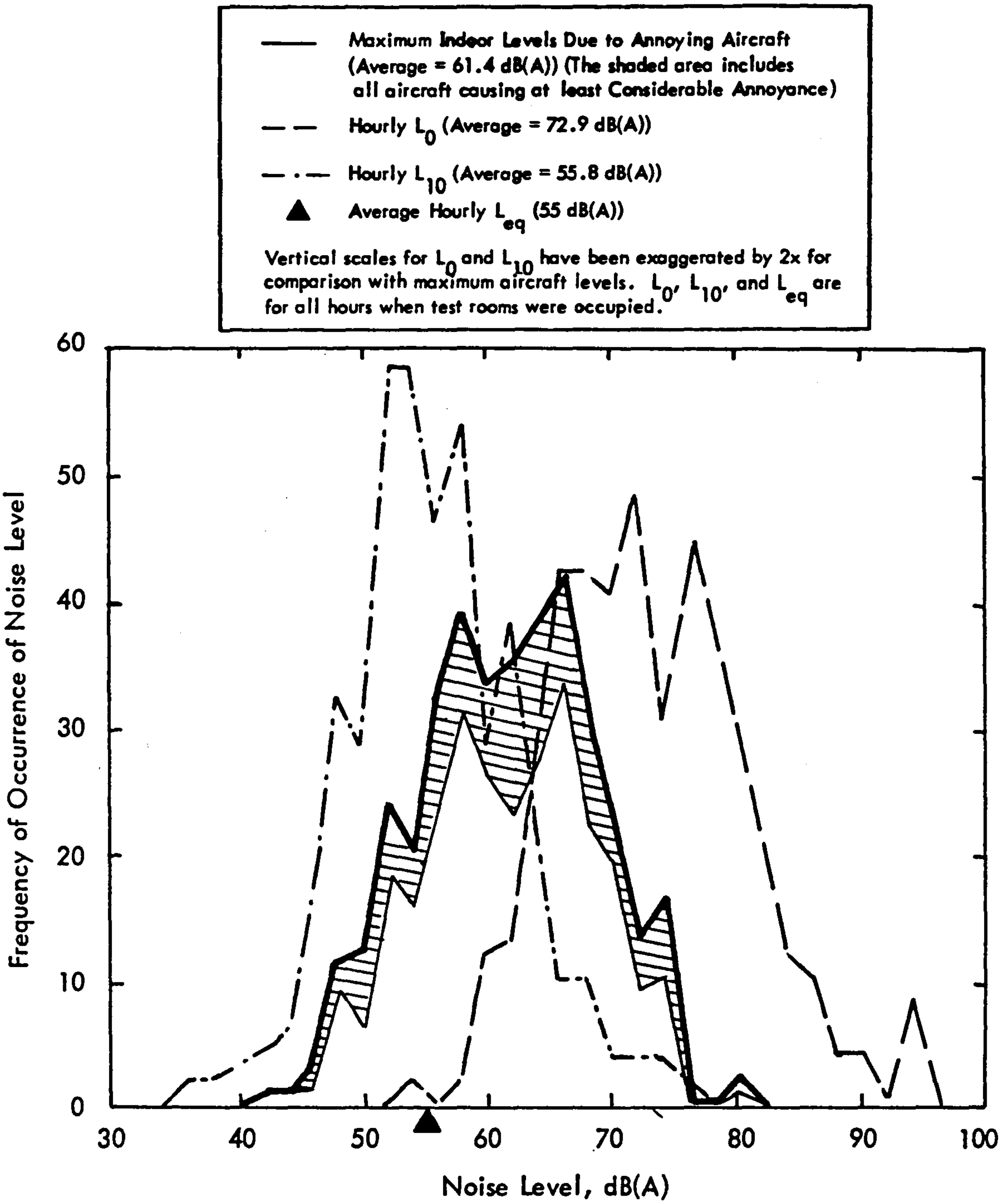


Figure 12. Comparison of Distributions of Indoor Maximum Aircraft Noise Levels with L_0 and L_{10} Statistical Noise Levels

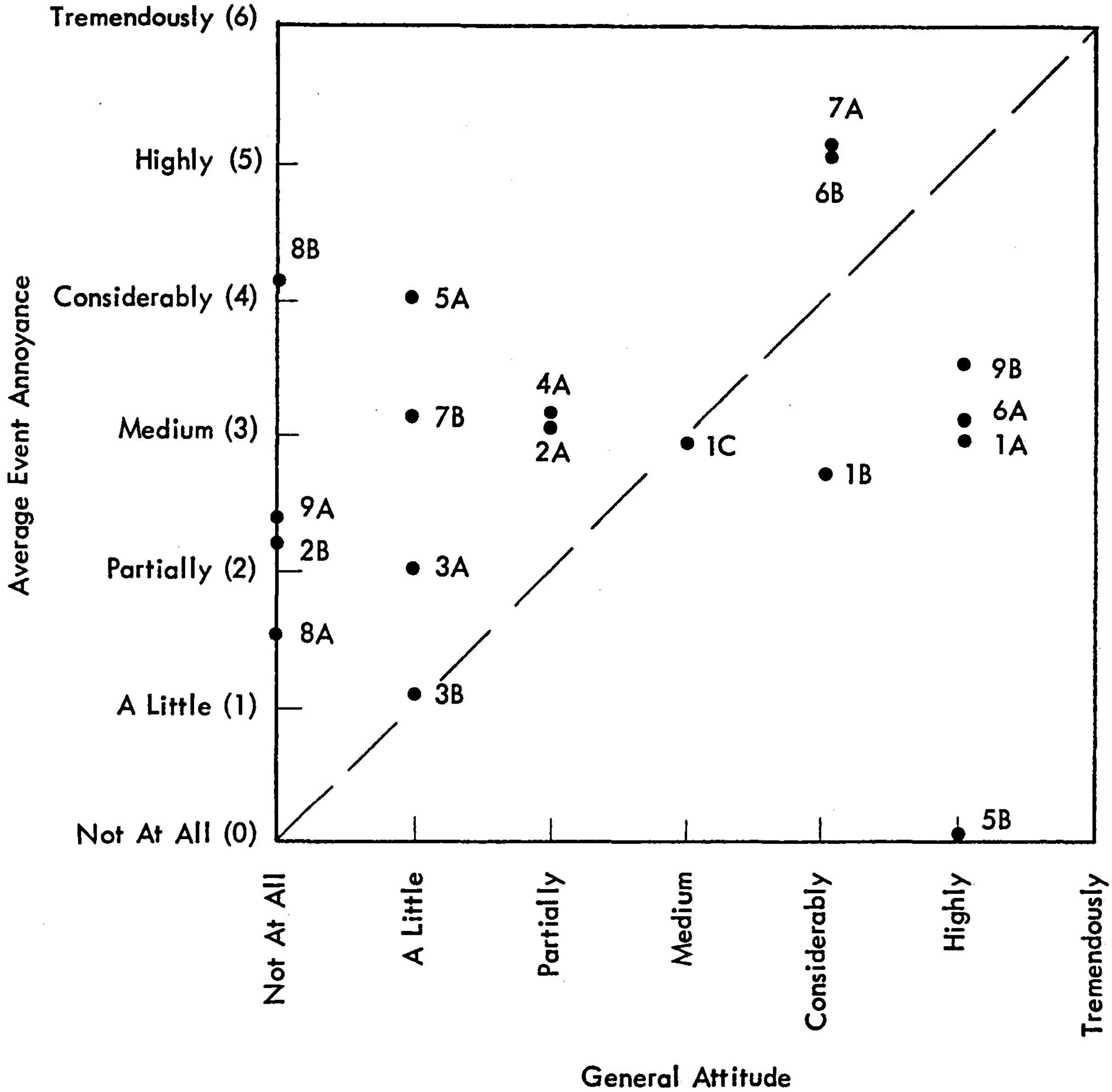


Figure 13. Comparison of Subject's General Attitude Toward General Aviation Aircraft Noise with Average Annoyance at Individual Aircraft Events

surprising, then, that the diary entries do not occur during hours of unusually high noise levels. Figure 14 superimposes the distributions of sound levels for hours when the respondents were annoyed over the same distributions for all hours <u>when the test room was occupied</u>. Although annoyance was recorded during only 29 percent of the total hours when the test rooms were occupied, the distribution of the noise level statistics are nearly identical for both cases. In particular, the average L_0 (maximum) levels for hours annoyed and for hours when test rooms were occupied are 72.9 dB(A) and 73.4 dB(A), respectively; similarly, the average L_{10} levels are 55.8 dB(A) and 56.2 dB(A) for these two cases. Thus, these noise metrics cannot be reliably correlated with annoyance due to the general aviation aircraft.

If the most readily available indoor noise statistics are ineffective for this limited sample in explaining the annoyance reactions for this study, what noise metrics can be used? This issue is clouded by the complexity of the annoyance reaction recorded in the pilot study.

The moderate degree of annoyance found in the pilot study is a reflection of the noise impact of the Torrance Airport on the neighborhoods in this study. The outdoor day/night average noise levels (discussed in Section 2.4.4) in these neighborhoods were never higher than 65 dB, which can be considered close to a minimum level defining noise-impacted areas.[3] Since the typical aircraft noise level in this study was not excessive, many factors combined with the actual loudness of the aircraft to produce the typical annoyance response, as shown by inconsistencies in the subjects' reactions. For example, at Site 9A (at which there were always at least 20 diary entries per day), one day there was a fairly good positive correlation between annoyance and indoor maximum aircraft noise level, while on another day there was a negative correlation (for both days, the average indoor maximum noise levels from aircraft were the same to within 1 dB, as were the indoor average (L_{eq}) levels).

From the data analysis, a general picture emerges of a noise level threshold below which prediction of the degree of annoyance is extremely difficult. In the pilot study, the vast majority of events appeared to fall below this threshold. As evidence of an annoyance threshold, Figure 15 shows the ratio of the number of diary entries of at least considerable annoyance (all entries of value 4 or greater on the six-point scale) to the number of all diary entries. The horizontal axis in this

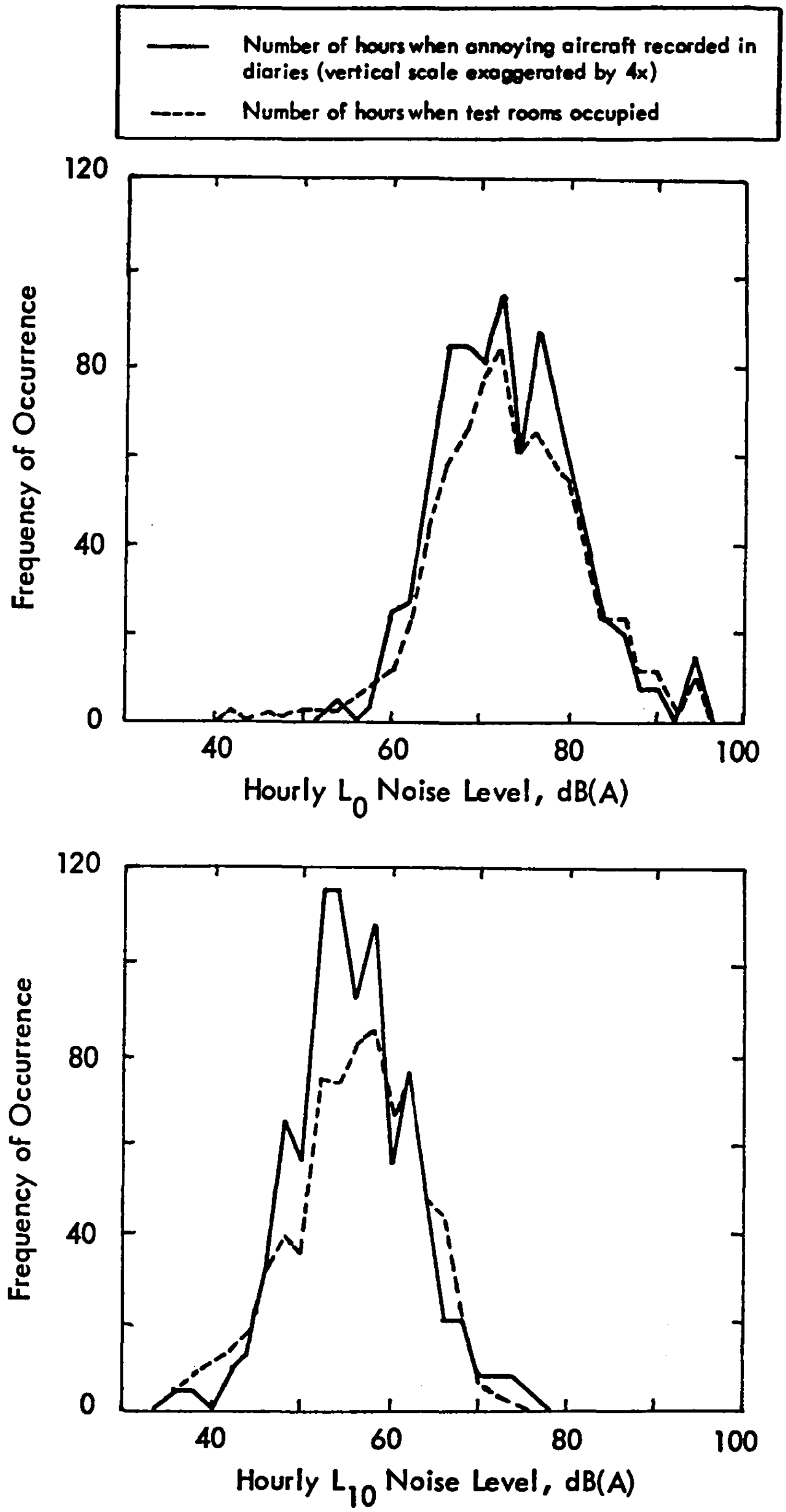


Figure 14. L_0 and L_{10} Statistical Noise Levels – Comparison Between Hours when Annoying Aircraft Were Recorded and Hours When Test Rooms Were Occupied

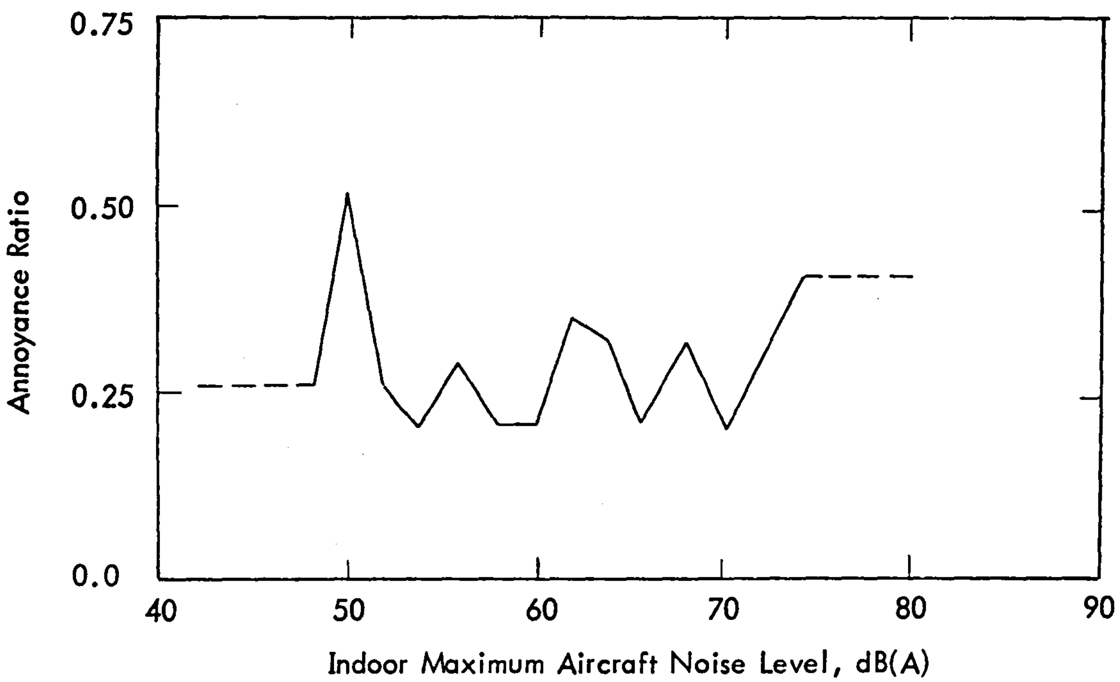


Figure 15. Ratio of the Number of Diary Entries for At Least Considerable Annoyance to the Total Number of Diary Entries vs Indoor Maximum Aircraft Noise Levels (all sites except 5B and 9A)

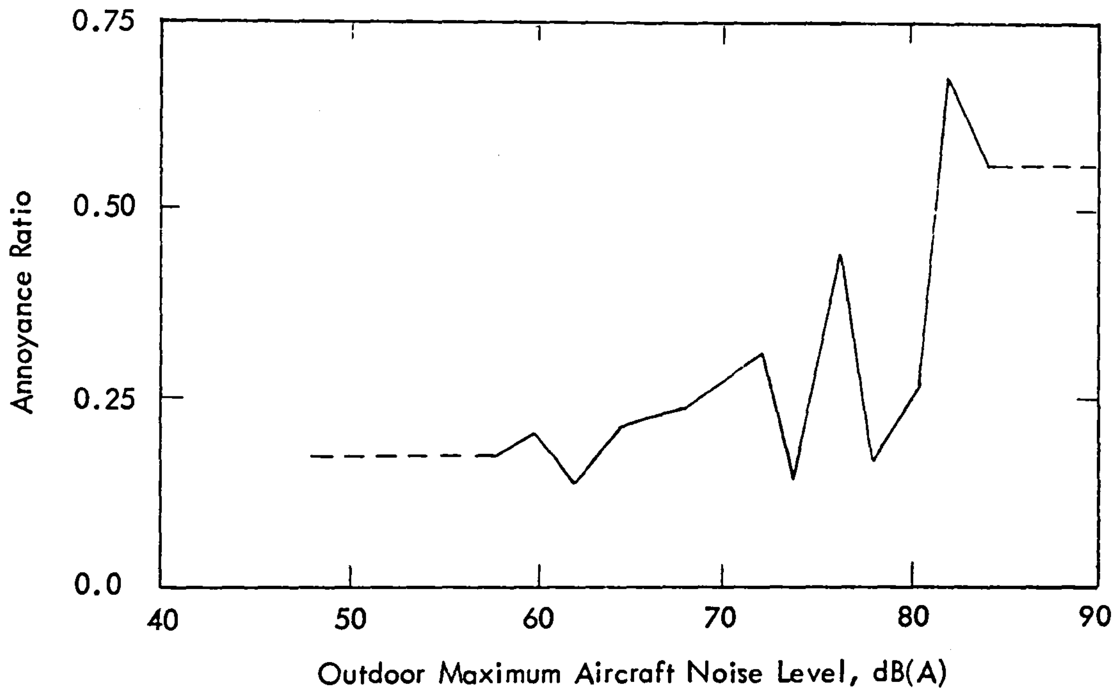


Figure 16. Ratio of the Number of Diary Entries for At Least Considerable Annoyance to the Total Number of Diary Entries vs Outdoor Maximum Aircraft Noise Levels (all sites except 5B and 9A)

figure is the indoor maximum aircraft noise level. The vertical axis is the ratio of diary entries of at least considerable annoyance to total entries. In this and the following graphs, results have been pooled into 2 dB bins, except near the endpoints where larger bins are used to ensure at least 10 total diary entries were used (this is indicated by a dashed line).

In Figure 15, for indoor maximum aircraft sound level below 70 dB(A), this "considerable annoyance ratio" is remarkably constant – approximately one aircraft event in four causes at least considerable annoyance regardless of sound level. Only when the indoor aircraft noise levels exceed 70 dB(A) is there a hint of significantly increased annoyance (other than an unexplained spike at 50 dB(A)).

The same data analysis using outdoor instead of indoor maximum aircraft noise levels produces better correlation between noise level and annoyance at high noise levels, as shown in Figure 16. One possible explanation for the improvement is that the indoor microphone may not accurately record sound levels as they are received by the respondent. The microphone frequently is supposed to cover two or three rooms which, though separated by partial walls at most, still may have quite different responses to outdoor noise. The noise level of a given aircraft may vary considerably as the subject moves from room to room or toward a window. In such cases, outdoor sound levels measured by nearby airport monitor stations may be more consistent indicators of the relative noisiness of the aircraft as perceived by the subjects.

A second possible explanation is that the indoor noise environment is permeated with nonaircraft noises, increasing the chances of false identification of aircraft noise on the digital tape recordings. Several such errors were noticed during the pilot study data analysis when the supposed indoor aircraft noise level greatly exceeded the actual outdoor noise level, and more such errors are suspected to exist.

Effect of Number of Recorded Events

One further evaluation was made of the correlation between the average annoyance response and the maximum indoor or outdoor aircraft noise levels, with or without a correction for the average number of events per hour noted by the subjects. This evaluation was intended primarily to see if such a correction might be indicated based on the "annoying event"-counting method employed in this pilot study.

The evaluation was made for the 10 sites out of all 19 possible sites for which there were valid indoor and outdoor maximum aircraft noise levels and corresponding annoyance response values for at least two 6-hour time periods over the 5-day test duration. Using the detailed data listed for Sites 1A, 1B, 1C, 2B, 3A, 3B, 5A, 6A, 7B, 9A, and 9B in Appendix B, the following site average parameters were defined:

- Average Annoyance Rating $\bar{R}$, weighted by the number of annoying aircraft events noted by the subject.
- Average Indoor Maximum Aircraft Noise Level, $\bar{L}_{max}$ (Indoor), weighted, on an energy basis, by the number of annoying aircraft events.
- Average Outdoor Maximum Aircraft Noise Level $\bar{L}_{max}$ (Outdoor), also weighted on an energy basis by the number of annoying aircraft events.
- Average Hourly Rate $\bar{N}$ of annoying aircraft events during the time the subject occupied the test room. (This was taken to be the total number of such events for a given site divided by the appropriate total number of subject test room hours for that site.) For purposes of correlation with annoyance, this hourly rate, which varied from a minimum average of 0.2 per hour at Site 3A to a maximum of 5.4 at Site 9A, was converted to decibel notation by adding $10 \log(\bar{N})$ to either the indoor or outdoor maximum level.

The best correlation, with an r of only 0.386, was between the average annoyance rating $\bar{R}$ and the average maximum indoor noise level $\bar{L}_{max}$ (Indoor). This relationship, a marginal one at best, is shown in Figure 17.

The regression lines for the four combinations of metrics vs annoyance that were evaluated were as follows:

$$\bar{R} = \begin{cases} 0.23 + 0.041 \left[\bar{L}_{max}(\text{Inside}) + 10 \log \bar{N}\right], & r = 0.314 \\ 0.69 + 0.030 \left[\bar{L}_{max}(\text{Outside}) + 10 \log \bar{N}\right], & r = 0.271 \\ -0.66 + 0.056 \left[\bar{L}_{max}(\text{Inside})\right], & r = 0.386 \\ -1.20 + 0.054 \left[\bar{L}_{max}(\text{Outside})\right], & r = 0.384 \end{cases}$$

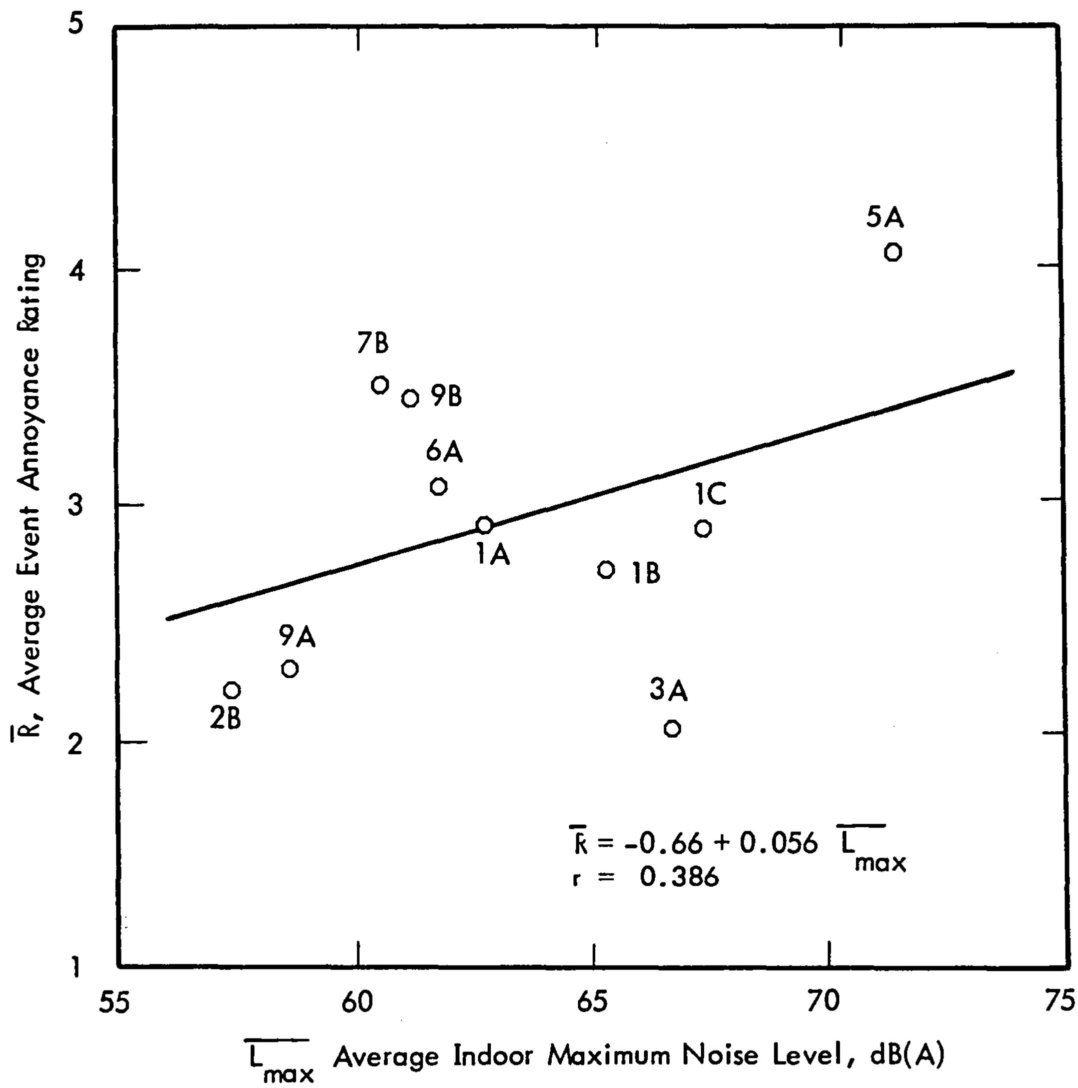


Figure 17. Correlation Between Average Indoor Maximum Noise Level for Aircraft Flyover and Corresponding Average Annoyance Rating. Data shown only for sites which have two or more valid indoor and outdoor measurement periods.

Clearly, these limited results do not indicate any improvement in the dose-response relationship when an approximate correction is added for the rate ($\bar{N}$) of annoying events noted by the subject. Furthermore, the outdoor maximum aircraft noise level is nearly as good a predictor as the indoor maximum level. (The average indoor to outdoor noise reduction for the aircraft, according to those data, was 9.2 dB with a standard deviation of 3.0 dB.) A final check on this type of correlation was carried out by comparing the same average annoyance response and indoor or outdoor average noise level (L_{eq}). As expected, the correlation was even worse (the correlation coefficient between $\bar{R}$ and $\bar{L}_{eq}$ (Indoor) was actually slightly negative).

2.4.4 Other Factors Mediating the Annoyance Response

All conclusions drawn in this section are tentative, not only because statistical tests have not been carried out per se, due to a small sample size, but also because the depiction of the relationships between each pair of variables given below conceals the potentially important contaminating influences of other variables.

Ambient Noise

The relation of the ambient levels to intrusive noise levels is one of the most obvious factors which mediates the annoyance response. Figures 18 and 19 show the same data analyses as Figures 15 and 16 but the noise metric is now the difference between maximum aircraft noise levels and the corresponding hourly indoor baseline ambient noise level (L_{90}). Again, the strongest correlation between noise and annoyance appears when outdoor aircraft noise levels are used. The inclusion of ambient noise in the metric appears to further improve the correlation a little, probably because the metric now corresponds better to some measure of detectability of the aircraft noise. In each of the four noise annoyance ratio graphs (Figures 15, 16, 18, and 19), the data suggest thresholds below which none of the metrics considered gives any significant correlation with annoyance. The data presented in the last annoyance ratio graph (Figure 19) are replotted in Figure 20 to show the actual distributions of diary entries at each level of annoyance as functions of the previously defined noise metric. It is important to note the large extent of overlap between levels of annoyance; compared to the ranges of variations within each level of annoyance, the change in average annoyance from one level to the next is small. Although these changes are not monotonic, there is an increasing trend in the annoyance rating from little (1) to highly (5) when the

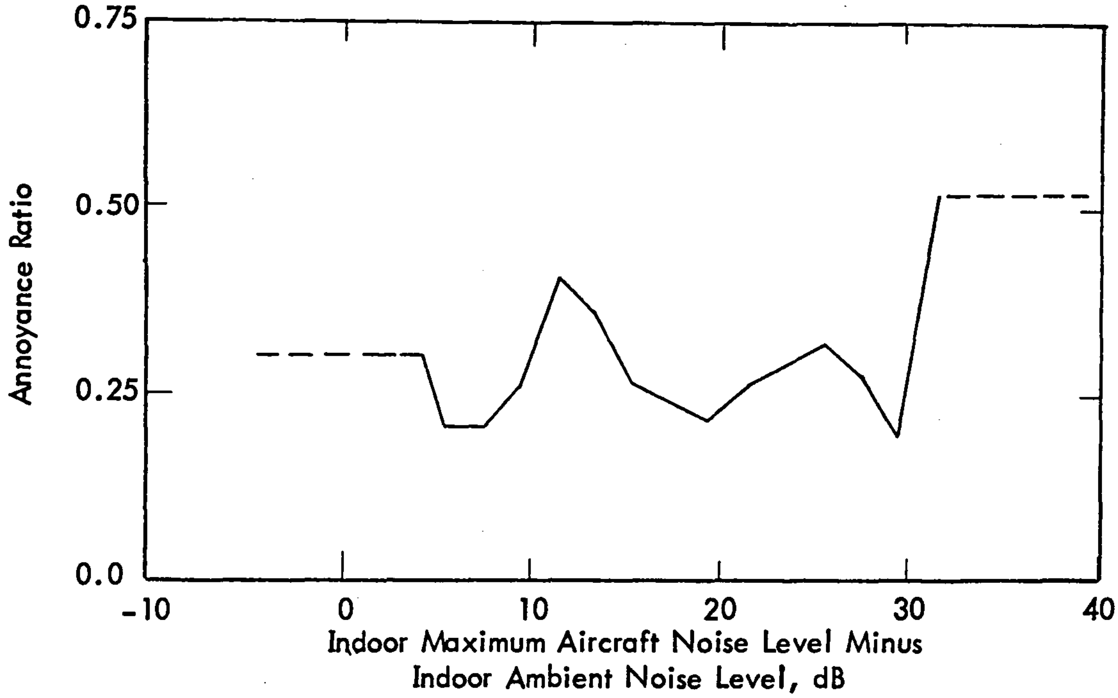


Figure 18. Ratio of the Number of Diary Entries for At Least Considerable Annoyance to the Total Number of Diary Entries vs Indoor Maximum Aircraft Noise Levels Minus Ambient (L_{90}) (all sites except 5B and 9A)

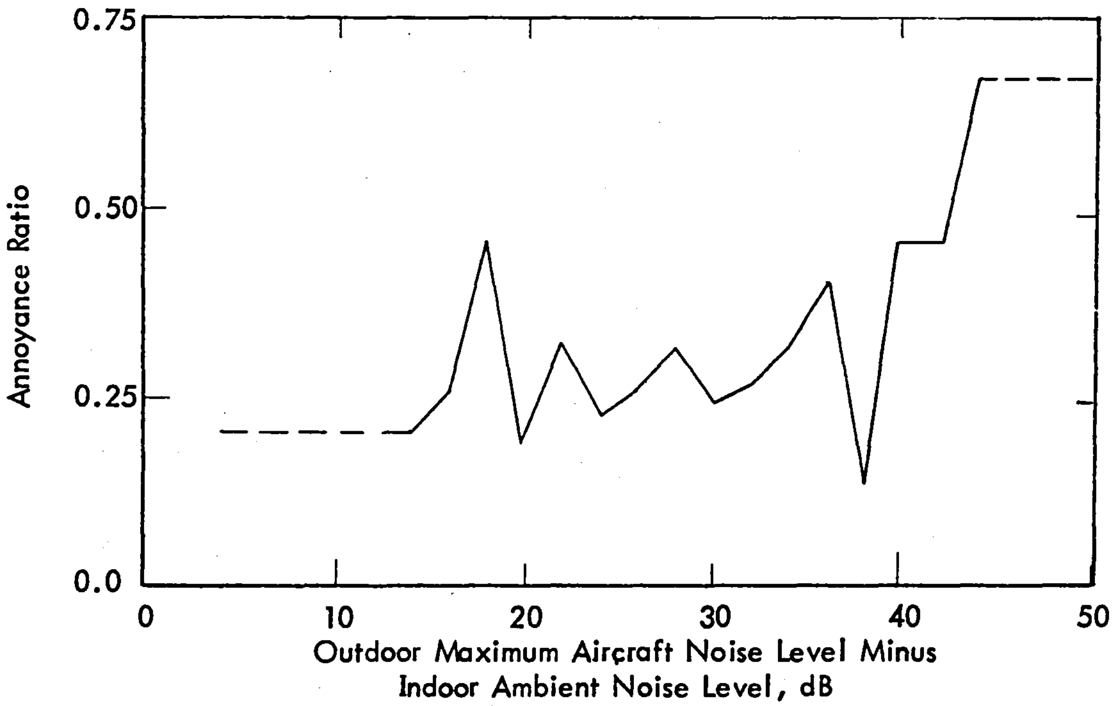


Figure 19. Ratio of the Number of Diary Entries for At Least Considerable Annoyance to the Total Number of Diary Entries vs Outdoor Maximum Aircraft Noise Levels Minus Ambient (L_{90}) (all sites except 5B and 9A)

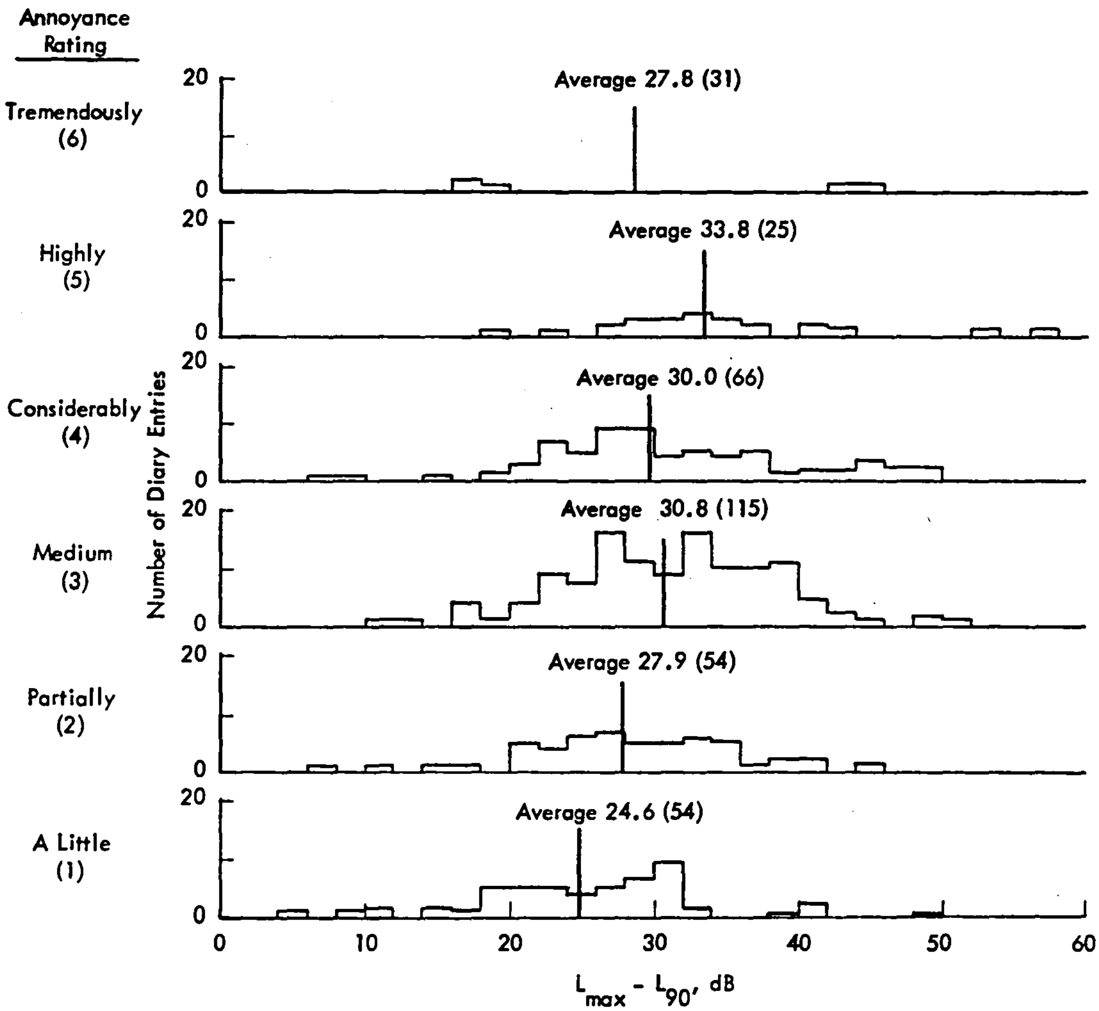


Figure 20. Histograms of Diary Entries for Annoyance vs Outdoor Maximum Aircraft Levels (L_{max}) Minus Baseline Indoor Ambient Noise Levels (L_{90})

difference between outdoor maximum noise level and indoor ambient (L_{90}) noise level increases by about 9 dB from a value of 25 dB to about 34 dB. At the highest annoyance rating, however, not enough entries are made to help validate this trend.

The L_{90} noise statistic is a measure of the ambient noise floor. It may be useful in estimating the detectability of aircraft noise, and – as shown above – may well be a useful metric for evaluating the annoyance response. Another candidate for indoor ambient noise is the L_{eq} value. Unlike the L_{90}, this metric is particularly sensitive to the actual levels of the loudest sounds in the ambient. Since the loudest sounds in the typical household are nonaircraft, the L_{eq} may be useful in evaluating the indoor noise environment in terms of the subject's accommodation to nonaircraft noise. In fact, a very limited investigation does indicate that higher indoor noise levels seem to correspond to a reduced sensitivity to aircraft noise.

Time of Day

Another important factor affecting the annoyance reaction is the time of day when annoyance is registered. In part due to the Torrance Airport nighttime curfew on takeoffs, few diary entries were made late at night. Out of a total of 782 diary entries, only 15 were made between 2200 hours and 0700 hours. For all sites, excluding Sites 5B and 9A, these entries showed a slightly higher degree of annoyance, as shown in Figure 21 (at Site 9A, there was no significant change in annoyance). The outdoor aircraft noise levels were not much different from daytime levels, and the average nighttime indoor aircraft noise levels were 3 to 4 dB lower than daytime levels. This may be due to some subjects having closed their windows at night.

Because annoyance as measured in the pilot study was observed to increase slightly during nighttime hours, one might look for metrics of aircraft noise which depend on time of day to have some correlation with annoyance. One such metric is the day/night average sound level (L_{dn}). (For Torrance Airport operations, the Community Noise Equivalent Level (CNEL) is approximately 0.7 dB higher than L_{dn}.[4]) Figure 22 shows average L_{dn} levels for each airport noise monitoring station with the corresponding daily average annoyance for the households near that station. No strong correlation exists in Figure 22 between the day/night average sound levels and annoyance. However, the range of noise levels is narrow. For comparison, Figure 23 shows annoyance as measured by community action from a wider range of studies.[5] This graph covers a much broader range of noise levels that indicate the expected trend in increasing community response as L_{dn} increases.

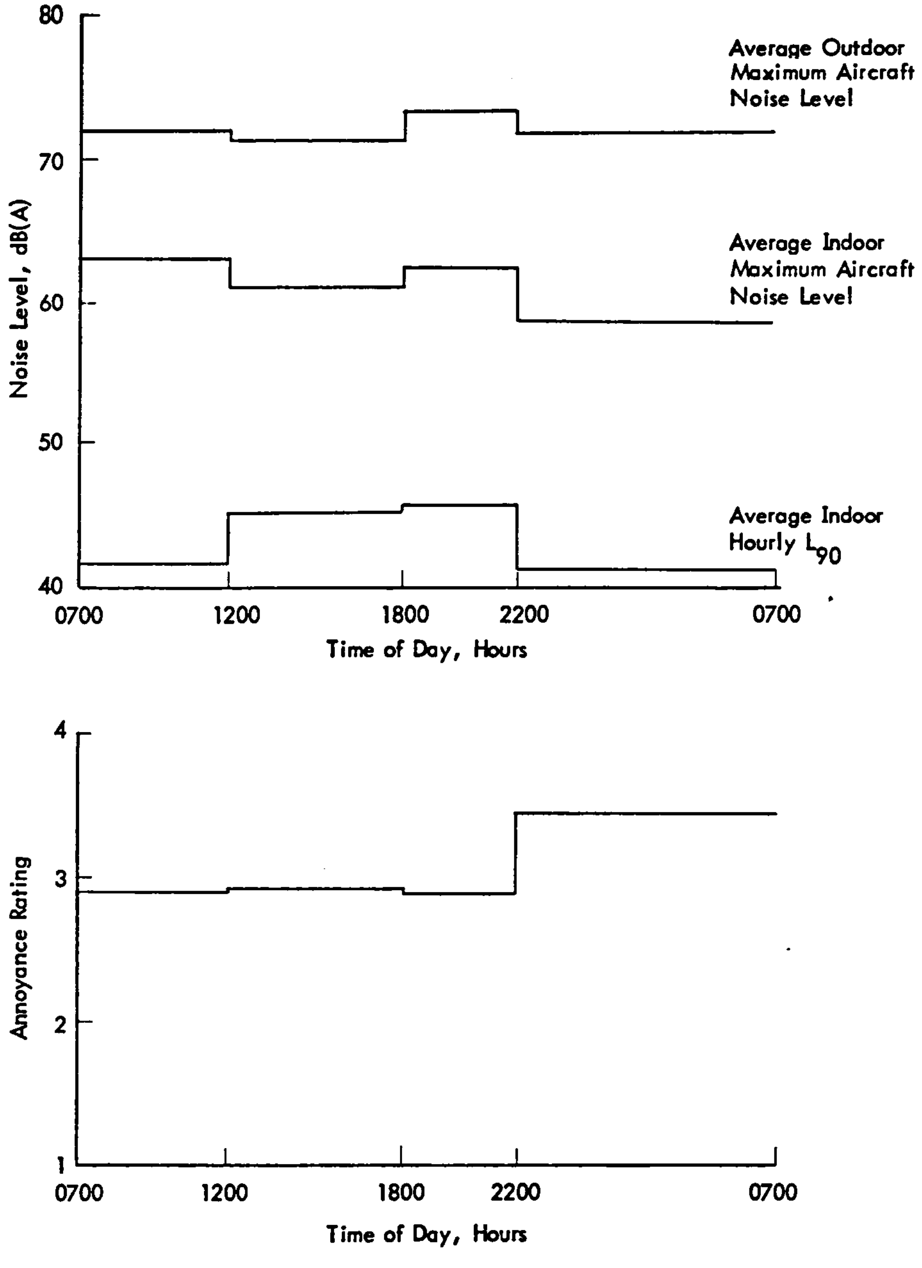


Figure 21 . Time Variations of Noise and Annoyance

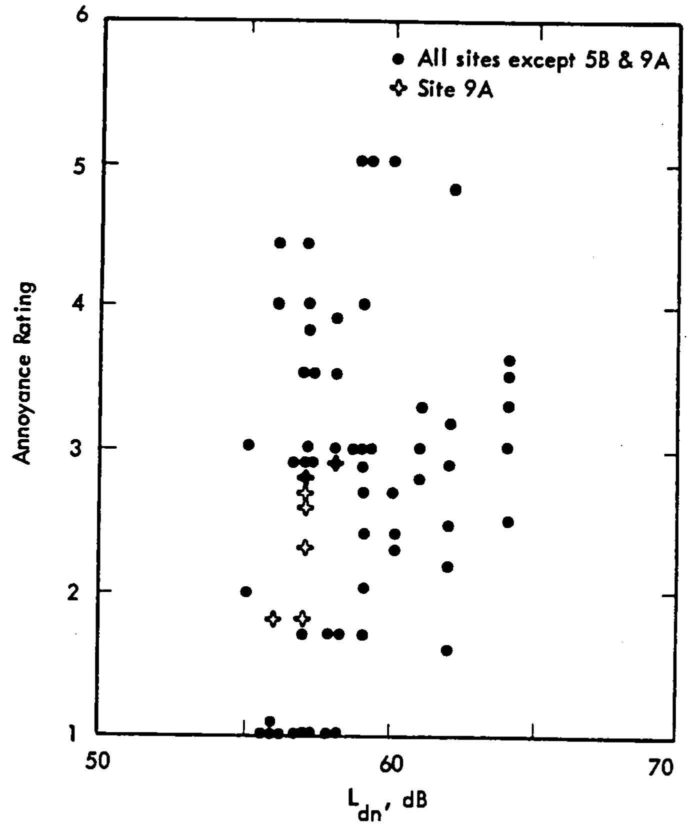


Figure 22. Subject's Daily Average Annoyance Ratings vs Outdoor Day/Night Average Sound Level (L_{dn})

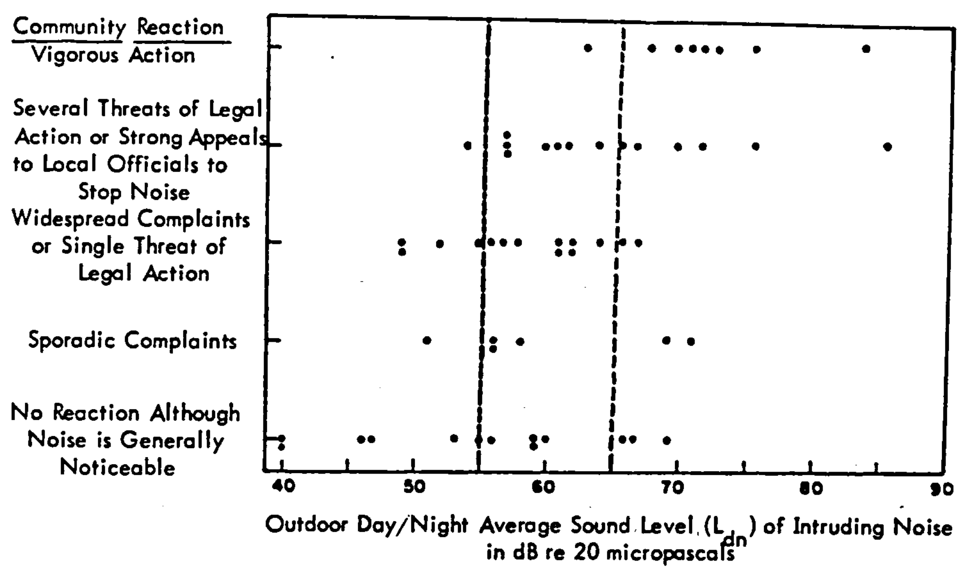


Figure 23. Community Reaction to Intensive Noises of Many Types as a Function of the Outdoor Day/Night Average Sound Level (L_{dn}) of the Intruding Noise (from Reference 5)

Location of Subject's Residence

Of the nine airport remote monitor stations, the number one station (Figure 3) is considered the most critical.[1] Close to this station, departure operations and local touch and go operations diverge. Because of the concentration of flights in this area, day/night average sound levels monitored at this station were higher than any other station (Table 5). As shown earlier in Figure 13, the three subjects whose residences were near the number one station (Sites 1A, 1B, and 1C) are clustered in the region corresponding to a general attitude of considerable annoyance with general aviation noise. Interestingly, however, these subjects on the average rated individual aircraft noise events as only medium annoying.

Subject's Activity Profile

Figure 24 shows histograms of where subjects spent their time, and what they were doing during the 5-day monitoring period. The possibility of relating aircraft annoyance to location or activity was made difficult in this experiment by the fact that subjects were asked to judge their annoyance only in the test rooms. Nevertheless, the most frequent annoyance response seems to coincide with sleeping activity in the bedroom.

Annoyance and Subject's Age

A relationship between annoyance and subject's age would indicate the importance in this type of study of selecting subjects with ages representative of the population residing near airports. Moreover, such subject selection might need weighting, in some way, by the time that various age groups spend at home. These potentially complicating factors make it desirable to determine whether age affects judged annoyance.

Figure 25 shows how the annoyance due to aircraft, when averaged across all the judgments of aircraft annoyance made by an individual subject, relate to his or her age. (The crossed data point is for a subject whose exact age was unknown.) No clear relationship was exhibited between a subject's age and the average annoyance. Although such a relationship might conceivably be demonstrated by a large sample, it is not likely to be a strong relationship. It appears justifiable to neglect age as a factor in selecting subjects in further, similar experiments. This conclusion applies to the age group 30 to 70; younger and older subjects may need to be considered further.

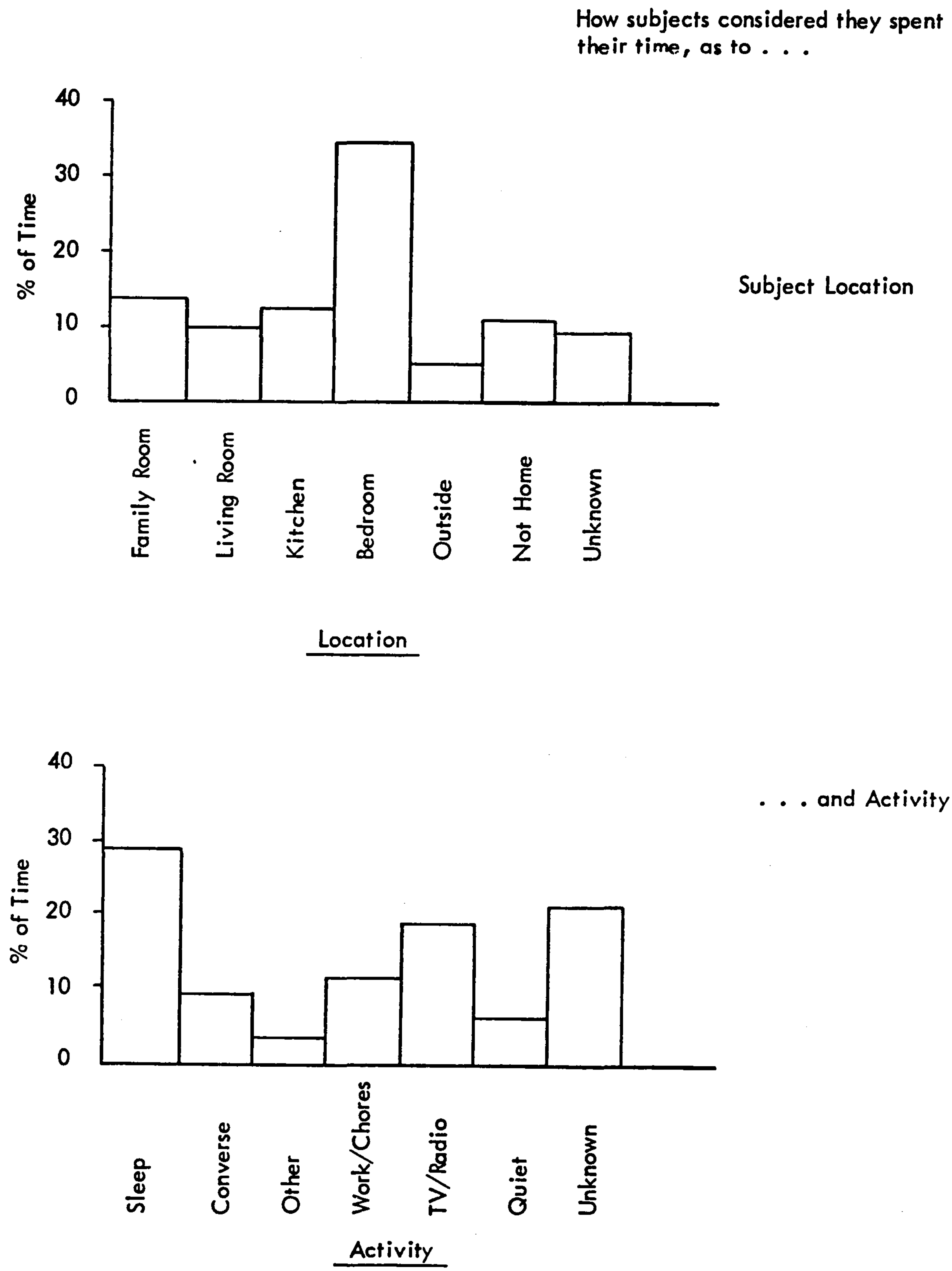


Figure 24. Distribution of Location and Activity by Time for Subjects During Monitoring Period

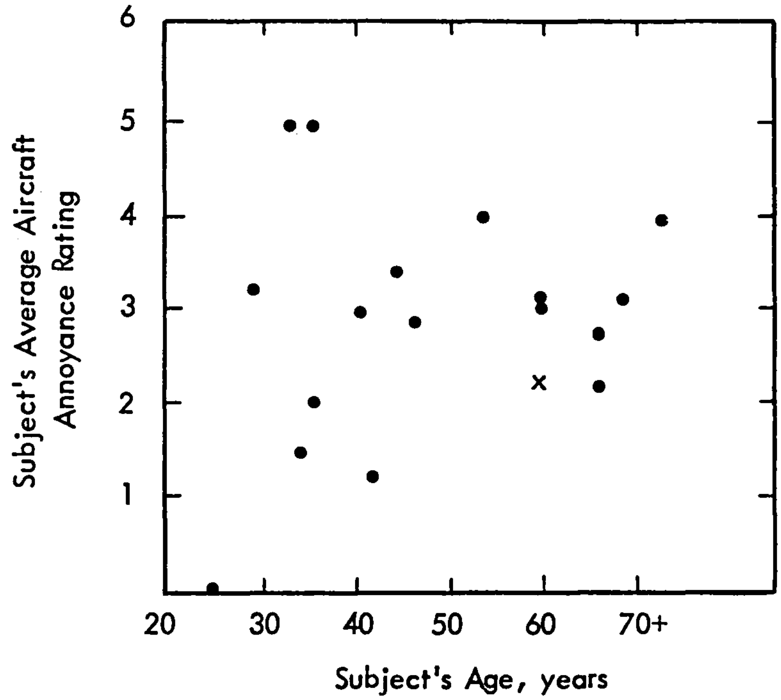


Figure 25. Subject's Annoyance vs Age. The vertical axis is the average annoyance rating due to aircraft in the time periods mentioned in Table 5, averaged for all the time periods in which a subject judged aircraft to be annoying.

Annoyance and Subject's Sex

A review of the program reveals that annoyance is apparently not dependent on sex. The noise annoyance rating for 10 females was 2.9; for eight males it was 2.8.

Annoyance and Subject's Belief that Noise Affects Health

One probable sensitive indicator of the significance of attitudinal effects is the importance of a subject's belief that "noise affects physical or emotional health and well-being" (see Recruitment Interview - Appendix A). Table 6 shows how annoyance, averaged over time and across subjects who shared a common belief in the effect of noise on health, compares.

Table 6

Aircraft Annoyance vs Belief that Noise Affects Health

Belief that "Noise Affects Physical or Emotional Health and Well-Being"		
"Yes" (5 Subjects)	"Maybe" (4 Subjects)	"No" (9 Subjects)
2.9	3.7	2.5
Average Aircraft Annoyance Rating for Above Groups		

At first sight, Table 6 yields inconclusive results about aircraft annoyance level as dependent on the belief that noise affects health, because there is no monotonic relationship, positive or negative, between the two. An alternative conclusion, however, is that there may well be such a dependence, if one considers that people who answered "maybe" are those who are most truly concerned about their health - in contrast to those who answered "no" (who are not concerned) and those who answered "yes" (some of whom merely correctly believed that noise of much higher levels has proven health effects).

Neither of these tentative conclusions is well enough supported by the limited data to be statistically valid, and the basic dependence of annoyance from general aviation aircraft noise on attitudinal variables remains largely unexplored.

Number of Annoying Events and Type of Source

A common assumption in subjective acoustics is that there exists a specially noise-sensitive subgroup of the population. The existence of such a subgroup is of special interest in evaluating community response to noise. A plausible hypothesis regarding the behavior of such a subgroup is that they will not only be more annoyed by a given noise event, but they will have a lower threshold of annoyance; that is, they will be annoyed at lower sound levels than those at which others are annoyed. In the context of the Torrance Airport study, this might translate to a greater number of annoyance judgments, given that aircraft generated a wide range of noise levels at any given site.

A review of the distribution of number of annoyance judgments per subject for each of four types of noise sources (i.e., aircraft, vehicle, other unspecified outside and other unspecified inside) reveals that most subjects perceived fewer than 50 events per source type as annoying over the experiment, but a few subjects perceived many more than 50 events as annoying, and did so for aircraft exclusively. One explanation for this could be the special sensitivity of five of the subjects to aircraft noise. This explanation must be viewed cautiously because the experiment was oriented overtly towards aircraft noise, even though subjects were asked about all types of noise. Moreover, some (but not all) of these ostensibly more sensitive subjects lived near the end of the runway when exposure to takeoff noise levels was greatest.

3.0 OBSERVATIONS ON RESULTS OF THE PILOT STUDY

Observations of the pilot study are presented in two categories. First are comments on the effectiveness and implementation of the methodology employed for measurement and correlation of subject annoyance and the associated interior and exterior noise environment. Second are general observations regarding the interpretation of the noise and annoyance data measured in this study. Section 4.0 discusses the application of the pilot study methodology to a national general aviation airport noise study.

3.1 Comments On Pilot Study Methodology

In the pilot study, the measurement process was designed to examine the individual annoyance event in detail, and involved considerable labor. Subject recruitment involved visiting a large number of residences. Data collection required diligent subjects willing to accept locating noise level recording equipment in each household. Data analysis involved identifying each annoying aircraft event in tape recordings, and correlating the event's loudness with information from diaries. The results of this analysis show that:

- Energy average aircraft noise levels did not dominate indoor noise environments.
- The annoyance reaction could vary considerably and inexplicably from one individual to the next.
- The best dose-response correlations observed occurred between annoyance and maximum aircraft (single event) noise levels.
- An unexpectedly large number of residences must be visited – an average of nine in the pilot study – before an available and willing subject is found. This made preselection of residences, for example on the basis of construction or location, difficult.
- In essence, the pilot study methodology consists of giving a subject a set of instructions and a diary and then launching him or her on a prolonged experiment. Therefore, instructions must be made abundantly clear and the diary format kept extremely simple to avoid any misleading trends from developing in the type or degree of recorded responses. (The diary format shown in Figure 7 was the result of several revisions made in this direction.)

- Because significant variations can occur in a single subject's response strategy from day to day, surveys like the pilot study must be taken over several days to allow averaging over these variations. An alternative approach would be to define at the outset that the subject's initial responses are the truest and that later responses reflect reduced attention or accumulated habits. (However, the limited data analysis from the pilot study does not support this last view.)

- Because of the low aircraft noise intrusiveness, identification of aircraft noise in indoor noise level recordings becomes an arduous and error-prone task when carried out manually. (An automatic aircraft signature recognition system would have been very useful.) Moreover, there appears to be limited correlation between indoor noise levels received by a stationary recording device and the actual noise levels received by a moving subject. If the time and effort of monitoring indoor aircraft noise levels are deemed acceptable, subject annoyance response should be restricted to the immediate vicinity of the recording equipment or, alternatively, the subject should be equipped with a wearable noise dose recording device.

In conclusion, methods such as the one used in the pilot study which require recording individual annoyance reactions may not be as well-suited to a national study. For the latter, large numbers of households can be surveyed in an efficient manner using, for example, telephone surveys. However, where a detailed evaluation of local community reactions are desired to relatively low level intrusive events, the type of methods employed in this study are more appropriate.

3.2 General Observations Regarding Study Results

- The residential neighborhoods sampled in the pilot study were not heavily noise-impacted by the Torrance Municipal Airport, despite their proximity to the runways. The noisiest neighborhood, surrounding the airport in the vicinity of Noise Monitor Station Number One, was exposed to day/night average sound levels (L_{dn}) below 65 dB for the time that Sites 1A, 1B, and 1C were observed. Average aircraft noise levels seemed to fall below a threshold where clear relationships between such noise levels and annoyance can be easily defined.

- General aviation single event aircraft noise levels measured in this study are not so intrusive as to dominate indoor residential noise environments. Maximum indoor noise levels due to aircraft were, on the average, 12 dB below noise peaks due to other sources. This means that the overall hourly statistical levels such as L_0 or L_{10} (as produced by the digital recording system used in the pilot study) cannot be used to reliably describe aircraft noise. Instead, indoor aircraft maximum noise levels must be laboriously identified by visual inspection of stripchart recordings or by some sort of aircraft signature detection system. Assuming the indoor environments surveyed in the pilot study were typical, then outdoor noise levels would have to be at least 12 dB higher (i.e., L_{dn} over 70 dB) before aircraft noise dominates the indoor noise environments.

- Annoyance as measured by the diary entries was, on the average, moderate. Most subjects expressed a lesser degree of annoyance when asked about their overall attitude toward general aviation noise. An interesting exception is the trio of residences near the airport Noise Monitor Station Number One, which is the noisiest neighborhood surveyed in the pilot study owing to its location in the path of departing aircraft.

- Whether indoor or outdoor maximum aircraft noise levels are used, results of the pilot study show that when indoor ambient levels are subtracted from these levels to arrive at the noise metric, a slight improvement in correlation with annoyance is observed.

- The general approach for evaluating subjective response to moderate level intruding aircraft noise events proved to be a viable one suited for detailed investigations of dose-response relationships in situ. A major improvement in the data acquisition method, however, would be to use personal, wearable noise dose recorders for each subject.

4.0 OBSERVATIONS REGARDING DESIGN OF A NATIONAL STUDY

The overall goal of the pilot study was to evaluate methods for measuring the impact of aircraft noise created by operations at general aviation airports. Previous sections of this report have discussed the implementation and results of this pilot study. In this section, several elements of the pilot study will be summarized in terms of their applicability to a comprehensive national study.

4.1 Overall Methodology

In a national study, a statistically valid sample of general aviation airports should be selected across the nation. In the communities impacted by operations from these airports, a representative sample of residents would be selected as a source of acoustic and human response information. The national study must utilize efficient, cost-effective procedures for the measurement and analysis of the appropriate noise environments and the associated human response data. The time-consuming procedures for sample selection and aircraft noise measurement employed in the pilot study would be appropriate for such a large scale study when a large statistical sample is required to thoroughly evaluate individual noise dose-response relationships.

4.2 Site Selection/Subject Recruitment

A representative sample of homes in the vicinity of airports across the nation should be selected based on an appropriate mix of airport operations, geographic location, population density of the community, housing construction, housing orientation, and demographic factors relating to the residents. The scope of the study should permit a representative sample to be drawn from across the nation. The lengthy subject selection procedures utilized in the pilot study should therefore be modified for a national program. This would indicate that: (1) personal interaction with subjects must be minimal; (2) subject selection must be based on a procedure that does not "invade" the personal life of the resident; and (3) some procedure for developing a proper mix of demographic factors will be required.

The sampling plan for this study should satisfy two principal objectives. First, to produce a highly reliable design. A sample for which the resulting estimates have a very small sampling error would be of the order of 1,000 or more respondents. Second, to assure that there will be no geographical "gaps" in the

selection of respondents – either by design or through a random occurrence. In most cases, the first objective would be optimally satisfied by a design which allocates the sample roughly in proportion to the population density in the airport community. On the other hand, the second objective is maximized by using a uniform spatial distribution which totally ignores the population density in any geographical area. To meet both objectives to the greatest extent possible, a hybrid approach is recommended: approximately half of the sample would be allocated in proportion to the population and half allocated through a uniform spatial distribution. The two subsamples would then recombine using appropriate weighting techniques in order to produce estimates for the entire community.

4.3 Acquisition and Analysis of Acoustic Data

Noise measurement methodology is a fundamental element of a national study. One basic question which should be answered at the start of any study design is: should the intrusive character of general aviation aircraft noise be determined primarily through physical measurements and be based on a correlation of human response to intrusive levels, or should human response be evaluated in terms of nonacoustic considerations (i.e., location of home, nature of aircraft operation, etc.)? In essence, goals for any such program should be determined in light of a balance between noise measurements, human response, and other mitigating factors.

Relating to general aviation noise annoyance, other surveys have implicated factors which were not addressed in the pilot study. These factors include the spectral composition of the aircraft noise,[6] and prestress of subjects due to annoying nonaircraft noise.[7] The first of these factors involves an unreasonable amount of data recording and analysis except for very small scale surveys. The second factor was omitted from the pilot study analysis due to limitations on available data and resources. It should be pointed out that the effect of nonaircraft environmental noise on aircraft noise annoyance may be difficult to quantify. Nevertheless, owing to the possible importance of this factor, it should be included in the survey – either through monitoring of outdoor noise with acoustical instruments or through questioning of each subject.

4.4 Human Response - Measurement and Analysis

For the pilot study, noise annoyance was defined as a statistical average of a large number of recorded individual responses to single aircraft flyovers. Even assuming that the response data are an accurate measure of the subject's annoyance to the flyovers, this definition ignores cumulative effects which may manifest themselves only in questions directed at a subject's overall attitude toward general aviation noise. A second, and more common, methodology for measuring noise annoyance is to direct questions at these general attitudes (for example, by a questionnaire or interview) and to correlate the answers with long-term statistics describing the outdoor noise environments (References 6 and 8, for example).

The contrast between the pilot study and questionnaire method was illustrated earlier by the response of one subject who attached two short notes to her diary explaining how she really felt about aircraft noise. These notes succinctly expressed attitudes toward aircraft noise which could not be read in the diary entries alone. Because of the difficulties in quantifying such results for comparison with noise levels, large populations could not be efficiently surveyed in this manner.

The proper methodology for the national study will depend on the purpose of the goals of the noise survey. If the goal is to discern variations of individual responses to single noise events, then the detailed picture of human response that can result from the pilot study methodology is worth the required time and effort. If the annoyance due to certain specific types of aircraft is of interest, again the pilot study methodology could be useful. But for the goal of a more general view of annoyance caused by operations at general aviation airports, other methods appear more suitable; in particular, a questionnaire type of survey, coupled with comprehensive outdoor noise measurements, may be the best choice.

REFERENCES

1. R. Dixon Speas Associates, "Torrance Municipal Airport Aircraft Noise Control and Land Use Compatibility Plans - First Quarterly Aircraft Noise Evaluation," July 6, 1979.

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3. U. S. Environmental Protection Agency, "Public Health and Welfare Criteria for Noise, July 27, 1973," EPA Report No. 550/9-73-002, 1973.

4. City of Torrance, Environmental Division Planning Department, "Environmental Impact Report for Torrance Municipal Airport Master Plan," Report EA 74-26, June 1976.

5. U. S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety," March 1974.

6. Taylor, S. M., Birnie, S. E., and Hall, F. L., "Annoyance Due to General Aviation Noise," McMaster University, Department of Geography and Department of Civil Engineering, Hamilton, Ontario, Canada, July 1980.

7. "Annoyance Caused by Light Aircraft Noise," NASA Technical Memorandum TM-76533, March 1981.

8. Civil Aviation Authority of London, "Reaction to Aircraft Noise Near General Aviation Airfields," DORA Report 8203, 1982.

APPENDIX A

Subject Recruitment Instrument

Attachment I

Revised Version

GENERAL AVIATION NOISE SUBJECT RECRUITMENT INSTRUMENT

Call Record Sheet

Address ____________________

City/Community ____________________

	DATE	DAY OF WEEK	TIME		RESULT	INTERVIEWER ID #
1)				am pm		
2)				am pm		
3)				am pm		
4)				am pm		
5)				am pm		

A1. RESPONDENT ID# ______________________________

A2. INTERVIEWER ________________ ID # ________

Introduction

Good Morning/Afternoon/Evening. I'm (. . .) from Wyle Laboratories in El Segundo (SHOW IDENTIFICATION). We are conducting a study for NASA and are looking for people who might be interested in volunteering their services.

We are interested in the impact of noise on the residents of this community. We need to find individuals who would agree to help us in a week-long experiment. This would involve measuring the noise levels in the household with a microphone system and having one of the residents provide daily information on the impact of noise. The information we get will be useful in assessing the level of noise in this community and will provide information which will be used for better environmental planning.

We are putting together a list of households which might participate in the experiment, and your household is a possible one.

Everything you tell us will be strictly confidential. Your name will not be connected in any way with this very important study.

A3. Would you be willing to discuss further the possibility of participating in our study?

YES..........................	(ASK A4)................	1
NO..........................	(TERMINATE)..........	2

A4. We need to have a number of households that have certain characteristics. First, we need to have households where an adult (OVER 18 YRS) is home most of the day.

Is there an adult in your household who is home during most of the day?

YES.. 1

NO.. 2

A5. Are you that person?

YES........................ (ASK A7) 1

NO........................ (ASK A6).................. 2

A6. May I please speak to that person

ARRANGE APPOINTMENT IF UNOBTAINABLE AT THIS TIME. THEN REPEAT THE INTRODUCTION TO NAMED PERSON.

A7. May I write down your name? ______________________

A8. Approximately what percentage of the day are you at home?

Less than 25% of the time, (TERMINATE)...... 1

25% to 50% of the time, (TERMINATE)........... 2

50% to 75% of the time, or (CONTINUE).......... 3

75% to 100% of the time? (CONTINUE).......... 4

A9. How good is your hearing? Would you say: CIRCLE APPROPRIATE CODE.

Very good, (CONTINUE)..................................	1
Good, (CONTINUE)...	2
Average, (CONTINUE)..................................	3
Poor, or (TERMINATE).................................	4
Very poor? (TERMINATE)..............................	5

(if the subject is acceptable, continue with the following questions)

Next, I'd like to ask you some questions about this area.

1. In general, how would you rate the area in which you live; that is, within a few blocks of here? Would you say it was:

Very good, ...	5
Good, ...	4
Average, ...	3
Poor, or	2
Very poor?	1

2. How quiet or noisy do you consider this area to be? Would you say: CIRCLE APPROPRIATE CODE.

Very quiet, ...	4
Quiet, ...	3
Noisy, or	2
Very noisy?	1

3. During which time periods does noise <u>annoy</u> you? Is it in the:

	YES	NO
Morning? (7AM-NOON)	1	2
Afternoon? (NOON-6PM)	1	2
Evening? (6PM - 10PM)	1	2
Nighttime? (10PM - 7AM)	1	2

4. I'd like to know whether noise interferes with any of the following activities. Does noise interfere with (. . .). READ a-e. CIRCLE APPROPRIATE CODE FOR EACH MENTION.

		YES	NO
a.	Sleeping	1	2
b.	Talking or Listening to the Radio, Watching TV, etc.?	1	2
c.	Reading?	1	2
d.	Resting?	1	2
e.	Outdoor activities?	1	2

5. Generally speaking, do you think noise affects your physical or emotional health and well-being?

YES	1
NO	2
MAYBE	3

6. (HAND CARD #1 TO R). Using this scale, in general, how annoyed would you say you are by noise in this area?
CIRCLE APPROPRIATE CODE.

TREMENDOUSLY ANNOYED	1
HIGHLY ANNOYED	2
CONSIDERABLY ANNOYED	3
MEDIUM ANNOYED	4
PARTIALLY ANNOYED	5
A LITTLE ANNOYED	6
NOT AT ALL ANNOYED	7

7. Now I'd like to explore some specific noise sources that may or may not annoy you in this area.

Using this same annoyance scale, please tell me how annoyed you are by each of the following noise sources [in this area (over the past year)] .[for clarification if necessary]

How Annoyed are You by Noise from (...)?	TREMENDOUSLY ANNOYED	HIGHLY ANNOYED	CONSIDERABLY ANNOYED	MEDIUM ANNOYED	PARTIALLY ANNOYED	A LITTLE ANNOYED	NOT AT ALL ANNOYED
Traffic or Motor Vehicles?	1	2	3	4	5	6	7
Emergency Vehicles/ Sirens?	1	2	3	4	5	6	7
Pets/Animals?	1	2	3	4	5	6	7
Neighbors (e.g.Noisy stereo,loud talking)?	1	2	3	4	5	6	7
Jet Airplanes?	1	2	3	4	5	6	7
Small Airplanes?	1	2	3	4	5	6	7
Helicopters?	1	2	3	4	5	6	7
Lawnmowers or Garden Equipment?	1	2	3	4	5	6	7

8. Are there any other noise sources that annoy you?

YES......................	LIST UP TO THREE MENTIONS	1
NO.........................	SKIP TO 9	2

1) ____________________
FIRSTMENTION

2) ____________________
SECOND MENTION

3) ____________________
THIRD MENTION

Finally, I'd like to ask you a few background questions.

9. What was the year of your birth?

YEAR __________

10. What was the highest grade in school you completed and received credit for?
CIRCLE ONE

00 01 02 03 04 05 06 07 08 09 10 11 12

COLLEGE/OTHER POST HIGH SCHOOL SCHOOLING: 13 14 15 16

POST GRADUATE SCHOOL: 17 18 19 20 OR MORE

11. Our intention is to gather information on a number of households in this area, and then select a number for the actual experiment. We expect that the experiment will take place sometime around (DATE).

Would you be willing to have us contact you again?

YES....................	(CONTINUE)............	1
NO	(TERMINATE)	2

12. We also might come back to ask some more questions. Is that all right?

YES....................	(CONTINUE)............	1
NO.....................	(TERMINATE)..........	2

13. Let me give you some information (HANDOUT) about our organization, and some telephone numbers where you can get hold of me. Also, can I get your telephone number so I can reach you again?

TELEPHONE #: ____________________

On behalf of Wyle Laboratories and NASA, I thank you for your cooperation. We will be getting back to you.

INTERVIEWER OBSERVATION SHEET

B1. Last* respondent was	Male, or	1
	Female?	2
B2. Last respondent's command of English was		
	Good, ...	1
	Fair, or	2
	Poor?	3
B3. Last respondent's hearing was		
	Good, ...	1
	Questionable, or	2
	Poor?	3

B4. Other observations: ____________________________________

____

____

*The last respondent is the one who answered questions 1 onwards. This may or may not be the person to whom you started talking.

WYLE LABORATORIES

7 August 1980

Dear Resident:

Wyle Laboratories is under contract to the National Aeronautics and Space Administration (NASA) to conduct a community noise survey. The goal of the survey is to evaluate methods for determining the noise environment in a residential neighborhood and to identify the major sources of noise to which people are exposed. The survey results will aid in establishing programs for the reduction of noise pollution.

To enable us to carry out this work, we request your cooperation in allowing our staff on your property to take noise measurements. If you choose to cooperate with Wyle and NASA in this program, we will:

1. Place a microphone inside your home to measure the noise from the community. If electric power is available, we would like to use it. This microphone is not capable of recording human conversation. It will be used only to measure the indoor noise environment for approximately 5 days.

2. Once each day a member of Wyle's staff will visit to change tape on the recorder and collect the daily log. This visit will be made at a time convenient for you.

3. At the conclusion of the 5-day period, the equipment will be removed from your premises.

Payment of $50 to you will be made for the use of your home during this period.

Two or three out of the following Wyle staff members may be involved in this program in your area: R. Brown, E. Croughwell, C. Kamerman, and D. May. They have been instructed to present a Wyle Laboratories identification card for your inspection, and will gladly tell you more about this program and the purpose of the measurements.

Thank you very much for any assistance you may be able to give us in this task.

Sincerely yours,

WYLE LABORATORIES
Wyle Research

Ron Brown

Ron Brown
Member of the Technical Staff

WYLE RESEARCH
128 Maryland Street, El Segundo, California 90245
213-322-1763 213-678-4251
TWX 910-348-6699 Cable WYLAB

APPENDIX B

Summary of Pilot Test Data

Table B-1

Summary of Test Data at Site 1A for Subject 1
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C(b) Event Level		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Wed. 8-6-80	1800-2200	2					58.2	60.4	79	-
	2200-0700									
Thurs. 8-7-80	0700-1200									
	1200-1800	3					60.8	63.8	93	80
	1800-2200	3	7	1.6	55.0	71.0	54.4	60.2	76	83
	2200-0700	1					53.2	54.0	62	75
Fri. 8-8-80	0700-1200	1	11	3.0	64.0	74.0	69.7	66.0	84	85
	1200-1800	1	3	3.0	65.0	77.0	61.8	63.0	81	80
	1800-2200	3	4	3.8	62.0	76.0	62.6	59.3	86	79
	2200-0700	2					62.5	55.0	88	72
Sat. 8-9-80	0700-1200	1	3	4.0	63.0	76.0	60.0	66.0	76	82
	1200-1800	2					-	64.1	-	83
	1800-2200	3	6	3.5	-	77.0	59.5	57.1	82	82
	2200-0700	2	1	2.0	-	70.0	49.4	54.4	72	77
Sun. 8-10-80	0700-1200									
	1200-1800									
	1800-2200	3					46.6	55.8	65	80
	2200-0700	2					45.1	53.5	47	77
Mon. 8-11-80	0700-1200									
	1200-1800									
	1800-2200	3					56.6	59.3	79	83
	2200-0700									
Tues. 8-12-80	0700-1200									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-2

Summary of Test Data at Site IB for Subject 9
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen, Living Room)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C[b] Event Level		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Mon. 9-9-80	0700-1200	3	16	3.1	63.1	76.3	59.2	61.0	76	
	1200-1800	3	6	2.5	67.3	74.3	55.7	64.5	84	
	1800-2200	2					51.0	52.5	71	
	2200-0700	1	1	5.0	56.0	79.0	48.9	51.0	60	
Tues. 9-10-80	0700-1200	4	38	2.3	60.4	72.8	56.0	62.6	76	
	1200-1800	4	7	1.6	58.7	71.0	62.7	63.1	81	
	1800-2200	4					54.1	58.5	76	
	2200-0700	1					52.6	52.0	69	
Wed. 9-11-80	0700-1200	5	3	2.7	65.3	75.7	53.5	58.9	96	
	1200-1800	1					62.1	57.0	77	
	1800-2200	4					58.1	58.4	87	
	2200-0700	1					50.2	55.0	56	
Thurs. 9-12-80	0700-1200	3	2	3.0	70.0	79.0	61.8	57.8	78	
	1200-1800	1	3	3.7	62.7	80.3	64.8	65.0	75	
	1800-2200	3					43.4	59.0	71	
	2200-0700	1					37.0	49.0	48	
Fri. 9-13-80	0700-1200	2	11	3.6	66.2	77.6	50.2	62.4	73	
	1200-1800	4	11	2.3	-	72.3	-	69.4	-	
	1800-2200	4					-	55.4	-	
	2200-0700	1	2	2.5	69.5	75.5	55.6	56.0	87	
Sat. 9-14-80	0700-1200	3	1	2.0	52.0	-	65.5	53.2	92	
	1200-1800	3	4	2.5	70.3	78.0	59.5	58.4	76	
	1800-2200	4	9	2.9	69.8	76.4	70.1	58.9	95	
	2200-0700	1					64.4	52.0	95	
Sun. 9-15-80	0700-1200	1					75.3	59.0	95	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-3

Summary of Test Data at Site 1C for Subject 10
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C(b) Event Level		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Mon. 9-9-80	0700-1200	2	2	3.5	66.0	72.5	63.0	61.0	79	
	1200-1800	3	4	3.3	68.3	77.3	66.5	63.4	82	
	1800-2200	1	1	3.0	95.0	71.0	68.8	64.0	95	
	2200-0700									
Tues. 9-10-80	0700-1200	3	4	2.8	65.8	72.3	61.2	62.7	82	
	1200-1800	5	5	3.0	68.0	76.8	62.8	62.9	94	
	1800-2200									
	2200-0700	1					37.3	54.0	58	
Wed. 9-11-80	0700-1200	1					53.0	57.0	73	
	1200-1800	5	4	2.5	69.3	72.8	60.7	62.2	90	
	1800-2200									
	2200-0700									
Thurs. 9-12-80	0700-1200	4	3	2.0	62.3	69.3	57.8	58.9	85	
	1200-1800		5	2.8	71.2	76.0				
	1800-2200	1					64.6	61.0	90	
	2200-0700									
Fri. 9-13-80	0700-1200	2	6	3.3	67.2	78.7	59.9	62.4	85	
	1200-1800	1	1	3.0	-	75.0	55.3	75.0	82	
	1800-2200	1					60.0	53.0	81	
	2200-0700									
Sat. 9-14-80	0700-1200	1	1	3.0	64.0	-	52.2	52.0	73	
	1200-1800									
	1800-2200	3					61.5	59.6	87	
	2200-0700									
Sun. 9-15-80	0700-1200	3	8	3.4	66.5	74.8	64.1	59.3	94	
	1200-1800	2	14	2.5	63.0	71.4	54.9	63.0	76	
	1800-2200	1	3	2.3	67.3	68.3	57.9	54.0	81	
	2200-0700									
Mon. 9-16-80	0700-1200	2	3	2.3	72.0	75.3	62.7	57.8	88	
	1200-1800		3	2.7	59.3	72.0				

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-4

Summary of Test Data at Site 2A for Subject 4
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Living Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[(a)]	Average A/C[(b)] Event Level		L_{eq}[(c)]		L_{max}[(d)]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 8-19-80	1200-1800	1					52.4	61.0	76	
	1800-2200									
	2200-0700	1					44.0	50.0	60	
Wed. 8-20-80	0700-1200	1					51.2	57.0	72	
	1200-1800									
	1800-2200	4					49.8	56.6	74	
	2200-0700	1					44.5	49.0	67	
Thurs. 8-21-80	0700-1200	2					48.9	58.8	69	
	1200-1800	2					46.0	58.5	69	
	1800-2200	4					48.0	56.6	73	
	2200-0700	1					42.1	49.0	65	
Fri. 8-22-80	0700-1200	2					51.0	60.5	79	
	1200-1800									
	1800-2200	3					45.7	52.5	71	
	2200-0700	1					35.7	51.0	52	
Sat. 8-23-80	0700-1200	1					49.2	57.0	66	
	1200-1800	1					43.7	60.0	61	
	1800-2200	1					59.6	52.0	80	
	2200-0700									
Sun. 8-24-80	0700-1200	1	2	3.0	61.5	66.5	51.9	56.8	72	79
	1200-1800	6					61.3	58.9	95	87

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-5

Summary of Test Data at Site 2B for Subject 6
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Living Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C Event Level[b]		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 8-19-80	1200-1800	5	5	1.8	56.6	72.4	51.2	59.7	69	80
	1800-2200	4	1	1.0	54.0	70.0	52.5	55.9	71	76
	2200-0700	1					39.6	54.0	57	
Wed. 8-20-80	0700-1200	5	1	1.0	60.0	63.0	51.9	59.0	71	78
	1200-1800	3	2	1.0	55.0	63.5	55.2	58.1	83	85
	1800-2200	3					56.8	57.0	76	
	2200-0700	1					45.9	49.0	66	
Thurs. 8-21-80	0700-1200	3	2	2.0	56.0	72.5	53.7	58.1	65	82
	1200-1800	3	3	3.3	53.3	69.7	50.8	59.3	69	
	1800-2200	3					48.1	56.1	70	
	2200-0700	1					48.8	50.0	77	
Fri. 8-22-80	0700-1200	4					56.2	60.8	71	
	1200-1800	3	1	2.0	60.0	74.0	51.6	61.1	73	84
	1800-2200									
	2200-0700									
Sat. 8-23-80	0700-1200	1					54.6	56.0	69	
	1200-1800	5	3	1.7	56.0	70.7	52.8	58.1	72	82
	1800-2200	4					56.2	53.1	78	
	2200-0700									
Sun. 8-24-80	0700-1200	3	3	2.7	61.7	66.7	54.1	56.4	72	79
	1200-1800	3	4	3.0	55.3	69.8	51.2	59.1	78	
	1800-2200	2					51.5	54.8	70	
	2200-0700	1					51.3	50.0	80	
Mon. 8-25-80	0700-1200	1					51.4	50.0	66	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-6

Summary of Test Data at Site 3A for Subject 15
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Living Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C[b] Event Level		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-30-80	0700-1200	1					52.7	57.0		
	1200-1800	3					59.7	57.6		
	1800-2200	4					61.5	55.1		
	2200-0700	1					53.4	51.0		
Wed. 10-1-80	0700-1200	5	1	1.0	59.0	64.0	60.1	56.9		
	1200-1800	6					54.8	56.6		
	1800-2200	3					40.0	54.2		
	2200-0700									
Thurs. 10-2-80	0700-1200	4					61.0			
	1200-1800	5					62.1			
	1800-2200	4					62.0			
	2200-0700	1					50.8			
Fri. 10-3-80	0700-1200	5	1	1.0	71.0	74.0	60.1	55.7		
	1200-1800	4					61.5	58.5		
	1800-2200	4					60.6	52.7		
	2200-0700	3					53.5	49.1		
Sat. 10-4-80	0700-1200	5					57.4	53.0		
	1200-1800	4					66.6	56.6		
	1800-2200	4	1	4.0	59.0	70.0	61.1	53.4		
	2200-0700	1					54.8	51.0		
Sun. 10-5-80	0700-1200	5					64.4	50.2		
	1200-1800	4					59.7	56.1		
	1800-2200	4					61.1	52.6		
	2200-0700	1					49.1	50.0		
Mon. 10-6-80	0700-1200									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-7

Summary of Test Data at Site 3B for Subject 16

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C Event Level[b]		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-30-80	0700-1200									
	1200-1800	1					54.0	59.0	71	
	1800-2200	2					53.3	52.5	75	
	2200-0700	2					59.2	50.5	72	
Wed. 10-1-80	0700-1200	3	1	1.0	54.0	53.0	52.3	57.2	78	
	1200-1800	4	1	1.0	62.0	68.0	56.7	56.9	78	
	1800-2200	4					56.5	53.6	76	
	2200-0700									
Thurs. 10-2-80	0700-1200	3	1	2.0	-	55.0	59.2		75	
	1200-1800	1					58.7		73	
	1800-2200									
	2200-0700	2					59.5		77	
Fri. 10-3-80	0700-1200	2					44.4	55.8	64	
	1200-1800	4	1	1.0	(65.0)	(61.0)	60.8	58.5	76	
	1800-2200									
	2200-0700	2					58.1	49.5	72	
Sat. 10-4-80	0700-1200	3					63.6	54.8	82	
	1200-1800	5					63.3	57.0	82	
	1800-2200	3					59.3	53.2	75	
	2200-0700	2					50.3	50.5	71	
Sun. 10-5-80	0700-1200	3	1	1.0	(33.0)	(58.0)	-	51.1	-	
	1200-1800	6					65.0	56.9	87	
	1800-2200	4					64.1	52.6	77	
	2200-0700	2					63.4	49.5	79	
Mon. 10-6-80	0700-1200	2					60.0	53.0	67	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Data in parentheses is questionable.

Table B-8

Summary of Test Data at Site 4A for Subject 19
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Living Room)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C(b) Event Level		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Mon. 10-13-80	1800-2200	1	1	3.0			42.1		64	
	2200-0700	1					39.8		59	
Tues. 10-14-80	0700-1200	1	1	2.0			44.5		66	
	1200-1800	1	4	2.5			47.1		65	
	1800-2200	1					54.2		70	
	2200-0700									
Wed. 10-15-80	0700-1200	1	4	2.5			48.8		67	
	1200-1800	1	1	2.0			46.1		68	
	1800-2200	1					49.2		65	
	2200-0700									
Thurs. 10-16-80	0700-1200		16	3.4						
	1200-1800	1	31	3.8			49.7		73	
	1800-2200	1					55.1		71	
	2200-0700	1					42.9		70	
Fri. 10-17-80	0700-1200		6	2.2						
	1200-1800	4	6	2.2			61.5		91	
	1800-2200	2					57.7		72	
	2200-0700									
Sat. 10-18-80	0700-1200		6	2.2						
	1200-1800									
	1800-2200									
	2200-0700									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed.
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-9

Summary of Test Data at Site 5A for Subject 7

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Living Room)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C[b] Event Level		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Mon. 8-25-80	0700-1200	3					50.6	57.8	74	
	1200-1800	1					49.4	59.0	73	
	1800-2200	4	1	4.0	76.0	84.0	56.9	59.3	79	84
	2200-0700		1	6.0	65.0	80.0				
Tues. 8-26-80	0700-1200	2					45.4	59.4	69	
	1200-1800									
	1800-2200	4					56.9	57.5	83	
	2200-0700									
Wed. 8-27-80	0700-1200									
	1200-1800	1					59.4	59.0	72	
	1800-2200									
	2200-0700									
Thurs. 8-28-80	0700-1200									
	1200-1800									
	1800-2200									
	2200-0700									
Fri. 8-29-80	0700-1200		1	2.0	52.0	74.0				
	1200-1800	2					45.3	-	73	
	1800-2200	4					58.9	56.9	79	
	2200-0700									
Sat. 8-30-80	0700-1200	1					51.3	63.0	73	
	1200-1800	2					46.0	59.5	68	
	1800-2200									
	2200-0700									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-10

Summary of Test Data at Site 5B for Subject 8
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Bedroom)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C Event Level(b)		L_{eq}(c)		L_{max}(d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Mon. 8-25-80	0700-1200	1					64.7	57.0	84	
	1200-1800									
	1800-2200									
	2200-0700	6					-	52.4	-	
Tues. 8-26-80	0700-1200	2					-	56.0	-	
	1200-1800									
	1800-2200	1					43.0	53.0	90	
	2200-0700	9					64.9	51.0	81	
Wed. 8-27-80	0700-1200	3					51.2	55.7	82	
	1200-1800	5					69.0	58.6	90	
	1800-2200	4					73.3	58.1	95	
	2200-0700	9					62.4	50.2	80	
Thurs. 8-28-80	0700-1200	5					60.7	58.7	89	
	1200-1800	2					68.7	65.4	92	
	1800-2200									
	2200-0700	7					37.4	50.8	57	
Fri. 8-29-80	0700-1200	5					66.9	57.2	82	
	1200-1800	6					69.8	57.5	90	
	1800-2200	4					76.0	55.0	93	
	2200-0700	9					71.2	51.6	90	
Sat. 8-30-80	0700-1200	5					55.8	58.7	85	
	1200-1800	6					66.5	61.5	87	
	1800-2200	1					67.7	56.0	75	
	2200-0700	5					52.6	51.5	77	
Sun. 8-31-80	0700-1200	4					56.4	60.3	76	
	1200-1800	2					48.6	57.0	68	
	1800-2200	3					63.0	56.0	87	
	2200-0700	8					46.3	48.8	73	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-11

Summary of Test Data at Site 6A for Subject 13
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Living Room, Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C Event Level(b)		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-23-80	0700-1200	1	1	5.0	67.0	-	50.0	56.0	66	
	1200-1800									
	1800-2200	1					58.2	51.0	77	
	2200-0700	1					57.4	52.0	71	
Wed. 9-24-80	0700-1200	2					54.1	55.5	75	
	1200-1800	5	2	4.0	67.0	67.5	55.9	57.4	79	
	1800-2200									
	2200-0700									
Thurs. 9-25-80	0700-1200									
	1200-1800	1					49.2	57.0	65	
	1800-2200	4	2	4.0	66.0	77.5	56.8	55.5	75	
	2200-0700	1	1	4.0	54.0	60.0	56.8	53.0	70	
Fri. 9-26-80	0700-1200	3	1	3.0	56.0	65.0	51.7	55.3	75	
	1200-1800	2	5	4.2	67.0	71.0	56.5	63.6	77	
	1800-2200	1	2	1.0	65.5	60.5	60.1	56.0	79	
	2200-0700		1	1.0	58.0	65.0				
Sat. 9-27-80	0700-1200	4	6	3.2	62.7	65.5	53.0	58.0	81	
	1200-1800	4	13	2.8	51.6	74.5	54.4	61.7	72	
	1800-2200	1					61.8	55.0	85	
	2200-0700	1					50.1	49.0	71	
Sun. 9-28-80	0700-1200	3	1	1.0	54.0	63.0	53.7	56.7	73	
	1200-1800	1	2	2.0	58.0	71.5	48.8	56.0	70	
	1800-2200	3					54.1	52.8	76	
	2200-0700									

(a) Annoyance Scale -
1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-12

Summary of Test Data at Site 6B for Subject 14

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Bedroom)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating(a)	Average A/C(b) Event Level		L_{eq} (c)		L_{max} (d)	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-23-80	0700-1200 1200-1800 1800-2200 2200-0700	3					59.6	62.6	86	
Wed. 9-24-80	0700-1200 1200-1800 1800-2200 2200-0700	1 4 1	1	5.0	48.0	56.0	44.8 57.9 45.9	56.0 57.2 51.0	67 92 71	
Thurs. 9-25-80	0700-1200 1200-1800	2 1					48.4 55.4	55.5 56.0	70 83	

(a) Annoyance Scale -
1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-13

Summary of Test Data at Site 7A for Subject 11

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[(a)]	Average A/C[(b)] Event Level		L_{eq}[(c)]		L_{max}[(d)]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-16-80	0700-1200 1200-1800 1800-2200 2200-0700	 3 2 					 62.3 61.7 	 56.8 54.2 	 92 	
Wed. 9-17-80	0700-1200 1200-1800 1800-2200 2200-0700	2 3 4 1					54.8 61.1 62.0 43.3	55.1 60.8 56.7 48.0	81 90 90 64	
Thurs. 9-18-80	0700-1200 1200-1800 1800-2200 2200-0700	2 1 2 					63.6 55.1 65.9 	58.2 55.0 54.5 	87 76 88 	
Fri. 9-19-80	0700-1200 1200-1800 1800-2200 2200-0700	2 5 4 1					58.6 60.3 61.3 45.5	53.5 55.6 53.1 50.0	79 86 89 74	
Sat. 9-20-80	0700-1200 1200-1800 1800-2200 2200-0700	2 1 3 					58.2 63.1 59.8 	56.5 54.0 50.8 	84 91 84 	
Sun. 9-21-80	0700-1200 1200-1800 1800-2200 2200-0700	1 2 2 	1	5.0	57.0	70.0	51.7 53.4 56.3 	50.0 55.5 50.0 	75 68 77 	
Mon. 9-22-80	0700-1200	2					58.1	53.5	81	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-14

Summary of Test Data at Site 7B for Subject 12

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C[b] Event Level		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 9-16-80	0700-1200									
	1200-1800	2					61.4	57.4	90	
	1800-2200	3					68.6	54.6	95	
	2200-0700									
Wed. 9-17-80	0700-1200									
	1200-1800	3	3	3.0	64.0	-	63.2	60.8	80	
	1800-2200	4					63.0	56.7	88	
	2200-0700									
Thurs. 9-18-80	0700-1200	1					51.2	55.0	71	
	1200-1800		2	3.5	60.5	65.0				
	1800-2200	2					53.5	51.5	77	
	2200-0700									
Fri. 9-19-80	0700-1200		1	3.0	63.0	65.0				
	1200-1800	1	1	4.0	56.0	58.0	64.0	56.0	78	
	1800-2200	3					56.5	52.2	79	
	2200-0700									
Sat. 9-20-80	0700-1200	2					53.2	56.5	85	
	1200-1800	2					63.7	54.0	85	
	1800-2200	4					61.4	51.4	82	
	2200-0700									
Sun. 9-21-80	0700-1200	2	1	3.0	72.0	-	59.1	51.1	81	
	1200-1800	1	1	3.0	67.0	-	64.3	55.0	85	
	1800-2200	3					56.9	50.4	73	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-15

Summary of Test Data at Site 8A for Subject 17
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C[b] Event Level		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 10-7-80	0700-1200	1					42.7		64	
	1200-1800	1	1	1.0			55.5		76	
	1800-2200	1					55.8		82	
	2200-0700	1					53.5		68	
Wed. 10-8-80	0700-1200	4					62.3		81	
	1200-1800	1					56.3		78	
	1800-2200									
	2200-0700	1					45.9		71	
Thurs. 10-9-80	0700-1200									
	1200-1800									
	1800-2200	2					61.0		87	
	2200-0700	3					47.8		77	
Fri. 10-10-80	0700-1200	5	7	1.7			61.2		88	
	1200-1800	1					52.0		74	
	1800-2200	3					60.2		88	
	2200-0700	1					39.2		43	
Sat. 10-11-80	0700-1200	2					-		-	
	1200-1800	2					58.3		81	
	1800-2200	1					62.7		86	
	2200-0700	1					58.9		79	
Sun. 10-12-80	0700-1200	2					60.2		80	
	1200-1800	2	2	1.0			59.7		85	
	1800-2200	1					54.6		72	
	2200-0700									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-16

Summary of Test Data at Site 8B for Subject 18

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C Event Level[b]		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Tues. 10-7-80	0700-1200									
	1200-1800	3					52.8		69	
	1800-2200	4					55.5		78	
	2200-0700									
Wed. 10-8-80	0700-1200	4					49.8		69	
	1200-1800	6					52.8		72	
	1800-2200	4					53.2		74	
	2200-0700	1					51.2		69	
Thurs. 10-9-80	0700-1200	5					46.9		64	
	1200-1800	6	4	4.8			55.8		76	
	1800-2200	4					56.4		77	
	2200-0700	2					49.5		70	
Fri. 10-10-80	0700-1200	4	3	3.7			50.6		76	
	1200-1800	5	1	3.0			54.9		75	
	1800-2200	4					52.1		73	
	2200-0700	2					53.6		75	
Sat. 10-11-80	0700-1200	2	1	3.0			48.2		70	
	1200-1800	6					52.6		75	
	1800-2200	4					56.0		75	
	2200-0700	1					51.2		65	
Sun. 10-12-80	0700-1200	2					44.6		68	
	1200-1800									
	1800-2200	2					56.7		68	
	2200-0700									

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-17

Summary of Test Data at Site 9A for Subject 2
Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[(a)]	Average A/C[(b)] Event Level		L_{eq}[(c)]		L_{max}[(d)]	
					Inside	Outside	Inside	Outside	Inside	Outside
Wed. 8-13-80	1200-1800	1	14	2.1	52.4	57.7	53.8	53.0	76	
	1800-2200	3	14	1.4	62.1	67.1	57.9	56.1	76	
	2200-0700		5	1.8	53.0	57.8				
Thurs. 8-14-80	0700-1200	5	43	1.6	57.0	64.4	55.8	55.8	74	79
	1200-1800	4	51	2.1	58.5	64.5	55.7	56.8	78	
	1800-2200	1	8	1.5	64.9	62.2	57.8	51.0	69	
	2200-0700									
Fri. 8-15-80	0700-1200	4	15	2.5	54.8	69.5	50.1	56.0	73	
	1200-1800	4	11	3.0	56.3	70.8	59.6	57.4	91	
	1800-2200									
	2200-0700									
Sat. 8-16-80	0700-1200	4	15	2.9	58.2	69.4	61.3	57.5	74	
	1200-1800	4	24	2.0	58.9	69.1	55.1	58.6	76	
	1800-2200	4	2	1.5	64.0	73.0	64.5	53.2	86	76
	2200-0700									
Sun. 8-17-80	0700-1200	1	11	2.7	54.7	65.5	48.6	55.0	69	
	1200-1800	3	18	3.0	56.7	68.3	53.5	58.5	70	
	1800-2200	4	5	2.8	58.4	62.0	60.2	52.4	95	75
	2200-0700		3	3.7	46.7	59.0				
Mon. 8-18-80	0700-1200	2	7	2.4	54.2	66.0	56.9	53.5	75	
	1200-1800	2	22	2.7	57.3	69.1	53.3	56.0	73	
	1800-2200	3	25	2.6	63.4	66.8	58.0	57.0	80	
	2200-0700									
Tues. 8-19-80	0700-1200	2	22	2.8	66.2	65.0	55.7	53.2	73	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

Table B-18

Summary of Test Data at Site 9B for Subject 3

Event level data are shown for aircraft events only. L_{eq} and L_{max} values are shown for those hours the subject was in the test room (Family Room, Kitchen)

Day/ Date	Time Period	Hours in Test Room	No. of Annoying Aircraft Events	Average Event Annoyance Rating[a]	Average A/C Event Level[b]		L_{eq}[c]		L_{max}[d]	
					Inside	Outside	Inside	Outside	Inside	Outside
Wed. 8-13-80	1200-1800	4	4	4.3	48.3	70.8	55.6	55.7	79	
	1800-2200		1	5.0	58.0	75.0				
	2200-0700	1	1	4.0	65.0	67.0	48.5	50.0	67	
Thurs. 8-14-80	0700-1200	5	3	3.7	50.7	65.3	49.4	55.8	69	79
	1200-1800	4	7	2.4	62.3	67.1	55.2	56.8	76	
	1800-2200									
	2200-0700									
Fri. 8-15-80	0700-1200	5	11	4.1	54.5	71.6	59.2	55.7	81	82
	1200-1800	6	7	3.4	61.6	69.3	52.3	57.6	81	80
	1800-2200	4					52.7	58.8	75	
	2200-0700	2					51.0	49.5	76	
Sat. 8-16-80	0700-1200	3	5	3.4	58.6	68.0	54.1	58.5	74	
	1200-1800	3	3	3.3	60.3	77.7	55.7	58.1	82	
	1800-2200	1	5	2.2	58.2	71.6	52.1	51.0	69	
	2200-0700									
Sun. 8-17-80	0700-1200	3	2	4.5	60.5	76.0	50.3	56.8	73	
	1200-1800	6	5	4.2	60.2	74.0	52.6	59.0	77	80
	1800-2200	5	3	3.0	64.3	68.3	56.4	52.4	84	75
	2200-0700									
Mon. 8-18-80	0700-1200	5	3	2.0	52.7	64.3	53.7	55.0	82	76
	1200-1800	6	8	3.1	63.4	69.5	57.5	56.7	81	81
	1800-2200	1	3	3.3	68.7	75.7	53.5	60.0	70	
	2200-0700									
Tues. 8-19-80	0700-1200	3	4	4.0	59.3	72.9	52.4	54.9	73	

(a) Annoyance Scale - 1 A Little Annoyed
2 Partially Annoyed
3 Medium Annoyed
4 Considerably Annoyed
5 Highly Annoyed
6 Tremendously Annoyed

(b) Arithmetic average of the maximum A-weighted levels.

(c) Energy average of the L_{eq} values for hours the subject was in the test room.

(d) Maximum A-weighted level occurring during the period subject was in the test room.

Dashes indicate data not available.

APPENDIX C

Measurement and Analysis Equipment

Table C-1

Equipment Utilized for Indoor Measurements During the General Aviation Noise Study

o B&K 4165 1/2-inch Condenser Microphone o B&K 2619 Preamplifier o Microphone Windscreen o Microphone Stand o B&K 181 Digital Recorder o B&K 183 Battery Charger o Digital Clock
Data Recording Parameters: Sound Level Range = 35 to 95 dB A-Weighted Sound Level Slow Time Constant One Sample per Second

Table C-2

Summary of Capabilities of Torrance Airport Noise Monitor System

MAP DISPLAY

- o Aerial Photograph
- o Digital LED Readout Each Second
- o Analog Meter Display
- o Remote Monitoring Stations (RMS)
  - Red - Inactive
  - Flashing Red & Green - Noise Limit Exceedence
  - Flashing Green - Aircraft Noise Event Being Monitored
  - Green - On Line & Monitoring Nonaircraft Noise Events

REMOTE MONITORING STATIONS (RMS)

- o 9 Residential Locations
- o 2 Airport Locations
- o Noise Samples Taken Every Half-Second and Returned by Phone Lines to the Noise Abatement Center in Both Audio and Digital Form

COMPUTER

- o UNIVAC Computer with 32,768 Word MOS Memory
- o Controlled Shutdown in the Event of Power Failure
- o Automatic Restart Capability
- o Magnetic Tape Memory Save Backup
- o Memory Allocation
  - 44,352 Single Event Records
  - 12 Yearly Reports
  - 144 Monthly Reports
  - 731 Daily Reports
  - 8,784 Hourly Reports
  - 3,264 Address/Registration Files
  - 200 Text Reports

CENTRAL PROCESSING UNIT

- o Audio Monitoring of Any RMS
- o Radio Monitoring of All FAA Tower Frequencies Plus Audio Time Code
- o Computer Clock Display
- o Selective RMS Display Showing Tenths of a Decibel
- o Data & Audio Patch Panel for Diagnostics
- o Direct Line Conversation Capability with Any RMS
- o Dual Stripchart Recorder Capability
- o Data Error Indicator Lights
- o RMS Control Box Door Open Indicator Lights
- o Automatic Noise Limit Exceedence Audio Signal

Table C-2 (Continued)

KEYBOARD/PRINTER

- o Handles Pre-Programmed Functions and Reports
  - Individual RMS Control for Thresholds and Limits
  - Flyover Plotting
  - Recap of Today's Noise Limit Exceedences
  - Recap of Yesterday's Noise Limit Exceedences
  - Daily Average Weather for Each Hour
  - RMS Calibration (Automatic or Selective)
  - Automatic Reports
    - Hourly Noise Levels - Total
    - Hourly Noise Levels - Aircraft
    - Hourly Noise Levels - Community
    - Daily Noise Levels - Total
    - Daily Noise Levels - Aircraft
    - Daily Noise Levels - Community
  - Address Label Printing
- o Controls Voice Actuate System for Tape Recorder
- o Automatic Printout of Any Aircraft Overflight

TAPE RECORDER

- o 20 Channel Automatic Record Capability
- o Automatic Digital Time Code Search Feature
  - 11 RMS's
  - 1 Audio Time Code
  - 1 Digital Time Code

MANAGEMENT INFORMATION SYSTEM

- o CRT with Keyboard
- o Hard Copy Capability
- o Features
  - Retrieval of Any Record from Memory
  - Averaging of Data
  - Data Plotting of CNEL, HNL, LDNC, LEQC and Histogram
  - Address/Registration Entry, Edit and Retrieval
  - Single Event Violation Identification by Aircraft Registration Number
  - Text Report Entry, Edit and Retrieval
  - Average Power Routine

ACOUSTIC COUPLER

- o Programming and Troubleshooting by Telephone

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16. Abstract

A pilot study was conducted to evaluate procedures for measuring the noise impact and community response to general aviation (GA) aircraft around Torrance Municipal Airport, a typical large GA airport. Elements of this study were examined in terms of their applicability to a comprehensive national program. The study employed Torrance Airport's computer-based aircraft noise monitoring system, which includes nine permanent monitor stations surrounding the airport. Wyle equipped 18 residences near these monitor stations with digital noise level recorders to measure indoor noise levels. Residents were instructed to fill out annoyance diaries for periods of 5-6 days, logging the time of each annoying aircraft overflight noise event and judging its degree of annoyance on a seven-point scale. Among the noise metrics studied, the differential between outdoor maximum A-weighted noise level of the aircraft and the outdoor background level showed the best correlation with annoyance; this correlation was clearly seen at only high noise levels, and was only slightly better than that using outdoor aircraft noise level alone. The results of this pilot study indicate that, on a national basis, a telephone survey coupled with outdoor noise measurements would provide an efficient and practical means of assessing the noise impact of general aviation aircraft.

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